

# ANNALS OF SURGERY

VOL. 113

MAY, 1941

No. 5



## TRANSACTIONS OF THE SOUTHERN SURGICAL ASSOCIATION

MEETING HELD AT HOT SPRINGS, VA.

DECEMBER 10, 11, 12, 1940

---

### ADDRESS OF THE PRESIDENT

---

#### THE STORY OF PLASTIC SURGERY\*

JOHN STAIGE DAVIS, M.D.

BALTIMORE, MD.

IN LOOKING ABOUT for a theme, which had not been considered in any Presidential Address in the more than half century of the life of this Association, I have chosen the story of plastic surgery.

In the limited time at my disposal, and because of the immensity of the subject, it will be impossible to even name more than a very few of those who have evolved the basic principles upon which modern plastic surgery is built, and who have set the milestones on the road, which all of us strive to follow. It is more than likely, also, that in the journey through the centuries which we are about to take, that some of the milestones themselves, may have been missed.

As far as I can ascertain, the oldest specialty is midwifery, the next in age is ophthalmology, and the records seem to show that plastic surgery is equally as old as ophthalmology.

From ancient times up to the seventeenth century, the care of wounds caused by war, which was almost as chronic a state then as in these enlightened modern days, was a great incentive toward the development of surgery. Many of the disfigurements of noses, ears, lips, etc., caused by war

---

\* Presented before the Fifty-third Annual Session of the Southern Surgical Association, Hot Springs, Va., December 11, 1940.

injuries, as well as by punishments for infidelity, thievery and other misdemeanors, stimulated the evolution of methods of plastic repair.

The history of plastic surgery through the ages is closely associated with operations for nasal reconstruction, and many of the principles evolved and general procedures employed in plastic surgery to-day, have been developed in this type of reconstructive work.

✓ Who coined the term "Plastic Surgery"? The title of Eduard Zeis' (1807-1868) book, published in 1838, was *Handbuch der Plastischen Chirurgie*, and he says: "As far as I know I was the first to use the words 'plastic surgery.'" The vastness of the literature on plastic surgery may be grasped when we realize that in his second book *Die Literatur und Geschichte der Plastischen Chirurgie*, published in 1863, Zeis collected the titles of over 2,000 articles on subjects dealing with plastic surgery, from the earliest times up to 1859. Since that time, during the last 80 years, many contributions to the subject have appeared, which, without doubt, more than equal in number the figures previously presented by Zeis.

✓ What do we mean by plastic surgery? Its *science* is the organized knowledge of the fundamental principles involved in the transplantation and shifting of tissues, with a clear understanding of what can be accomplished by this work. Its *art* is the application of this knowledge and the actual manipulative reconstruction. Its *field* extends from the top of the head to the soles of the feet.

✓ Plastic surgery is primarily that branch of general surgery which is distinctly formative or constructive. It deals with the repair of defects and malformations, either congenital or acquired; with the restoration of function and comfort; and incidentally with improvement of appearance, and consequent relief of certain psychoses due to consciousness of deformity. This is accomplished chiefly by readjustment of tissues or by the transfer of all types of transplantable tissues, either from the immediate neighborhood or from some distant location.

The deformities dealt with in plastic surgery, for the most part, involve the skin or adjacent soft parts of the entire body, but frequently the framework of bone or cartilage underlying the soft parts must also be reconstructed or readjusted. The treatment of large denuded surfaces, and of intractable wounds of all types, which require skin grafting or flap-shifting also belong in the field of plastic surgery.

There is another aspect of the subject, which may be called esthetic plastic surgery, and this deals with the correction of imperfections in human proportions, both real and fancied, and has as its primary object the restoration of symmetry of contour and improvement of appearance. There are well-trained and ethical surgeons who specialize in this aspect of plastic surgery,

The speaker illustrated his address by two groups of lantern slides: The first group showed the likenesses of a few of the men famous in the development of plastic surgery. The second group showed some of the types of cases which the plastic surgeon, in civil life, is called upon to treat.

but it must be understood that this is also the happy hunting ground of the charlatan and the quack.

From every standpoint, I believe that better results can be obtained by having plastic surgery a subdivision of general surgery, connected with great teaching hospitals, rather than have it, even if large endowments are available, as disconnected separate units or institutes without such connections. This is true both from the standpoint of the care of the patient and also from that of instruction and research, as it is essential to have the help and cooperation of the various preclinical and clinical departments as well as the dental, medical art, and laboratory divisions. The help of all these departments is frequently sought and is invaluable. It has been my experience that the Division of Plastic Surgery is used by practically every clinical department, both medical, surgical and dental at one time or another, so the cooperation is mutually beneficial.

Proficiency in plastic surgery demands the same familiarity with the fundamental medical sciences and the same application of surgical principles as is essential in any type of surgery with, in addition, a refinement of technic, a sense of geometric proportions, and an artistry not commonly called for in the execution of most surgical therapeutic procedures.

Strange as it may seem, even in 1940, when plastic surgery is spoken of, I venture to say that the majority of the medical profession immediately think of its esthetic aspect only and entirely forget the major reconstruction work by which human wrecks are restored to usefulness, both physically and mentally, and are enabled to again earn a living.

Some other misconceptions about the subject are that plastic surgery is confined to constructive work on the face; that it consists of skin grafting only; that it was entirely a development of the First World War (1914-1918); and that nothing of importance had ever been previously undertaken in plastic and reconstructive work. Unquestionably, the World War awakened general interest in the possibilities of the subject, but few additions were made to the basic principles of plastic surgery, which had been established long before. However, the large number of cases available made it possible to eliminate unsound procedures and to standardize and improve operative measures, particularly in certain groups of facial injuries.

It was my belief until recently that rhinoplasty and other plastic operations on ears, lips, etc., were described in the ancient Egyptian writings. In the Edwin Smith Papyrus, probably copied about 1600 B.C., injuries to the nose and its framework as well as wounds of the ear, upper lip and chin are reported, and methods of surgical treatment are given, but in the translation of this and other *papyri* and in other early records, I can find no mention of definite plastic procedures.\* Galen suggests that the Egyptians were well-acquainted with plastic procedures but they did not pass on their knowledge to others.

\* It is estimated that the original source, from which the Edwin Smith Papyrus was copied, was written between 3000 and 2500 B.C.

As far as I can ascertain, the earliest real plastic surgery was done by the Hindoos, and knowledge of the methods employed by them was carried by students and itinerant surgeons to Egypt, Greece and Arabia, and subsequently to the other Mediterranean countries.

The early Hindoo surgeons were required to undergo a long period of preliminary training, and the importance of a knowledge of anatomy was stressed. They developed great dexterity, and they excelled all other nations of their time in operative surgery. They were especially skilled in skin-shifting and other phases of reconstructive work. Sushruta, who was the father of Hindoo surgery, wrote his original *Samhitá* about 750-800 B.C., and this is based on the four sacred *Vedas*, which were written many years earlier.

Sushruta writes in detail of an operation for the reconstruction of a lost nose by the advancement of a cheek-flap, and this is the oldest known description of rhinoplasty. He also describes plastic operations for the repair of lips by means of cheek flaps, and also 15 methods of repairing split or mutilated lobes of ears. This method of utilizing sliding flaps was called, many centuries later, the French method.

Hindoo surgery began its gradual decline from the time of Buddha (562-552 to 482-472 B.C.). He and his followers gave great support to medicine, but all opportunity for surgical advance by animal experimentation, etc., was suppressed, as contacts with blood, pus and diseased tissues which were necessary in surgery were considered polluting. In time, the fundamental truths on which surgery had been based were lost and surgical practice was turned over to the lowest castes who were considered so unclean that they could not be further contaminated by doing surgical work.

These plastic operations in India, which the physicians did not condescend to perform, were delegated to certain members of the Koomá or Tilemaker caste, and the art was passed down from father to son.

The writings of Hippocrates, the Great (460-370 B.C.) and Aristotle (384-322 B.C.) contain no reference to skin-shifting or to plastic surgery. However, plastic procedures were apparently well-known in Rome at the beginning of, and during the first few centuries of the Christian era.

Aulus (Aurelius) Cornelius Celsus, who may well be called the Father of plastic surgery, was born in Rome about the time of the birth of Christ and died about A.D. 50. In the year A.D. 30, he wrote a book *De Re Medica* which is remarkable for its completeness and accuracy, and it is the oldest medical document after the writings of Hippocrates. In this book, in addition to other things, he described different plastic operations, among them the first operative treatment for ectropion, ptosis and entropion of the eyelids. He told how to repair with skin flaps from adjacent areas, mutilated ears, noses and lips where the loss of tissue was small. Although his knowledge of plastic procedures was undoubtedly derived from Hindoo sources, he does not mention the more extensive rhinoplastic operations performed by the Hindoos. He described an operation for the separation of fingers in

syndactylism; and a plastic operation on the penis to cover the glans with skin where circumcision had been too thoroughly done. He speaks of the treatment of lips accidentally torn or split, but I can find no mention of the treatment of congenital clefts of the lip.

The use of the ligature was described by Celsus in his seventh book, and was a well-known procedure in his period.

There are a number of reasons, which point to the fact that Celsus was simply a Roman gentleman with an intimate knowledge of medicine and that he was not a practicing physician. He was ignored by the Roman practitioners of his day, and Garrison says that his name is mentioned only four times by medieval commentators, in spite of his outstanding contributions. However, with the revival of learning, his book *De Re Medica* was one of the first medical books to be printed in 1487.

Antyllus, who lived in the first half of the second century A.D., described certain plastic operations, and his work is probably based on the writings of Celsus.

Claudius Galen (A.D. 131-201), greatest Greek physician after Hippocrates, was born in Pergamos, Asia Minor, and began to practice in Rome about A.D. 164. He was a most voluminous writer on philosophic and medical subjects, and his medical and surgical writings were for centuries the supreme authority in medical science. There was no appeal from what he wrote, and this point of view was maintained until the seventeenth century. The infallibility of Galen's theories and writings was first disputed by Leonardo da Vinci (1452-1519), and later by Andreas Vesalius (1514-1564), and others.

Galen described plastic methods for the repair of colobomata in the lips, ears, and alae of the nose with skin from adjacent areas, and many of his ideas on plastic procedures were very similar to those of Celsus, although Celsus was given no credit.

Oribasius (A.D. 325-403), describes the plastic operations of Galen and Antyllus, and Paul of Aegina (625-690) followed Galen's methods of treatment of nose and ear defects.

With Hippocrates and his followers, there was no distinction between medicine and surgery. However, Galen said, "surgery is only a mode of treatment," and in due time, following this as a lead, medicine was separated from surgery in about the seventh century. Avicenna (980-1037), the celebrated Arabian physician, treated the surgeon himself, as an inferior being. On the other hand, Lanfranc of Milan and Paris, who died in 1015, and others insisted that medicine and surgery should not be separated, and that a knowledge of medicine was as necessary to a surgeon as a scalpel. However, centuries were to pass and bitter controversies were to be waged between surgeons and barber surgeons, and between physicians and surgeons before medicine and surgery were placed on the same professional and social level.

Beginning with the time of St. Benedict, A.D. 525, many individuals re-

requiring medical and surgical treatment were taken care of in the monasteries by the monks, and, in time, the principle knowledge of medicine and surgery was to be found in the hands of the priesthood. From the ninth to the thirteenth century, the Jews shared with the clergy the monopoly in the healing art, having obtained their knowledge from the Arabs. With the exception of one or two meager descriptions of operations for the repair of congenital clefts of the lip and a few discussions as to whether noses which had been cut off could be replaced and would live, plastic procedures were apparently forgotten during this entire period.

In A.D. 1215, Pope Innocent III decreed that no priest, deacon or sub-deacon should perform any surgical procedures, which involved bloodshed, as it was incompatible with the divine mission. As a result, such procedures were turned over to barbers, bathkeepers, executioners, mountebanks, sow-gelders, and other individuals of low degree, much as had been done in India hundreds of years before.

About the middle of the fifteenth century, there lived in Catanea, Sicily, a family of the name of Branca, who came into prominence when it became known that they were able to reconstruct noses, which had been cut off, or had been destroyed by disease, and that they could also repair defects in ears and lips by utilizing flaps from the face or forehead.

It was also said that Branca could transplant successfully the nose of a slave to his master. Branca is thought to have been the first to use a flap from the arm to reconstruct a nose, but his son, Antonius, perfected the arm-flap operation, and to him belongs the credit of developing what is known as the Italian method. The earliest record of their work is found in the Annals of the World by Peter Ranzano, Bishop of Lucerne, in 1442.

A brief note found in a work on anatomy by Alexander Benedictus (1460-1525), published in Venice in 1497, describes how "a nose may be repaired by skilled persons by the use of an arm flap." Other surgeons, of more or less repute, were impressed with this work and various allusions, both favorable and derogatory, to the operation are to be found in surgical works of the sixteenth century.

In 1460, Heinrich von Pfolspeundt, a Bavarian army surgeon, wrote of the flap-from-the-arm method used by the Brancas for rhinoplastic restoration, and this was 126 years before it was described by Tagliacozzi. He obtained his knowledge of the method from individuals who had seen these rhinoplastic operations performed.

The use of the arm-flap in reconstructing a nose was mentioned by Gabriel Fallopius (1523-1562), Ambroise Paré (1510-1590), and Andreas Vesalius (1514-1564), but, principally, in a critical or in a skeptical vein.

The first systematic treatise on plastic surgery ever written was published in 1597, by Gaspar Tagliacozzi (1546-1599), the Professor of Surgery at Bologna. It was entitled *De Curtorum Chirurgia per Insitionem*, and was a volume of 298 pages, including 22 full page plates. In it, he described various plastic operations on the lips and ears, but gives special prominence

## STORY OF PLASTIC SURGERY

to his method of rhinoplasty, in which he used a pedicled-flap from the arm, but he makes no mention of anyone having previously performed a similar operation. This operation was undoubtedly based on the procedures of the Brancas, but is commonly called the *Tagliacotian or Italian* method, as the operation was brought to public attention and was popularized by him. His first rhinoplasty was performed in 1580, on Conti Brachetti di Modena, and his fame soon became widespread.

Tagliacozzi incurred the antagonism of the church, as his work was considered sacrilegious because he attempted to improve or undo God's handiwork. This religious persecution was carried on even after he had been buried, as his body was exhumed from consecrated ground in the Church of San Giovanni Battista and was buried elsewhere. All his books were called in by the church to be destroyed, but fortunately a number of them were saved and later editions published.

After the death of Tagliacozzi, several surgeons wrote of his methods, but in a few years Tagliacozzi's method was forgotten and soon became more of a legend than a reality, and, in the course of time, it began to be considered an impossibility.

Reneaulme de la Garanne (1712) tried to rehabilitate Tagliacozzi's arm-flap method of rhinoplasty, and proposed sewing the fresh flap into the defect, immediately after raising it, without waiting for it to granulate as was done by Tagliacozzi. This same idea was again suggested by von Graefe 100 years later.

The Indian method of rhinoplasty by means of a forehead flap was brought to the attention of European surgeons by a letter which was printed in the Gentleman's Magazine for October, 1794. It described in detail, with drawings, the reconstruction, by a member of the Tilemaker caste in India, of a nose which had been cut off. This operation had been observed by two medical men, Mr. Thomas Crusoe and Mr. James Findlay, of Bombay, and was the type which had been practiced from time immemorial in India by members of this caste.

The first English surgeon to make use of this information was Joseph Constantine Carpue (1764-1846), of London. He successfully performed rhinoplasty by the Indian method in September, 1814, and again in January, 1815, and subsequently performed other operations of the same kind. Thus the possibility of the restoration of lost noses was again brought to public attention, although not by the Italian or Tagliacotian method.

The use of the Indian method was introduced into Germany by von Graefe, in 1816, and Dieffenbach, in 1829; into France by J. Lisfranc (1790-1847), in 1826; and into the United States by J. M. Warren, in 1834. Since that time, this type of rhinoplasty, with the forehead flap, has been performed many times, by many operators, and with many modifications.

Tagliacozzi's arm-flap method of rhinoplasty was revived by Carl Ferdinand v. Graefe of Berlin (1787-1840), and he reported one successful case.

In 1818, he published a book called *Rhinoplastic*, the first monograph on rebuilding noses to be written since that of Tagliacozzi, in 1597.

Johann Friederich Dieffenbach (1792-1847), of Königsberg, was a genius in plastic surgery, and in his work and by his writings gave a tremendous stimulus to the subject. Many of his methods and principles have not been improved upon and are still constantly employed. When Dieffenbach visited Paris all of the hospitals were thrown open to him so that he could demonstrate his remarkable plastic work.

An interesting sidelight on Dieffenbach and early newspaper publicity may be gathered from a paragraph in Sir Astley Cooper's notebook, October 8, 1834: "Prof. Dieffenbach called without an introduction to ask me to go to the Hôpital de St. Louis with him to see him make two new noses, which I declined as I did not wish to be mentioned in the papers."

In Europe, during the first half of the nineteenth century, great strides were made in evolving plastic principles and in developing operative procedures. The transplantation of skin and other tissues as employed in plastic surgery was a development of the latter part of the century.

Four surgeons in the United States also did pioneer work in the subject, and their influence on plastic surgery in this country was of great importance. These men were John Peter Mettauer (1787-1875); Joseph Pancoast (1805-1882); J. Mason Warren (1811-1867), and Thomas D. Mütter (1811-1859). I shall take the time to briefly consider their work.

Doctor Mettauer was born in Prince Edward County, Va., and received his A.B. degree at Hamden-Sidney College in 1806. He then went to the University of Pennsylvania and obtained his M.D. degree in 1809. He was a diligent student, an insatiable reader, and throughout his long life kept himself fully informed of advances in medicine and surgery.

At first his work was in general medicine, which included surgery, but his remarkable skill attracted many patients from all parts of this country, and soon he was able to devote his attention almost entirely to surgery. In 1837, he organized his group of private students into a Medical Institute, which, in 1848, became the Medical Department of Randolph-Macon College, and continued so until the suspension of that school in 1860. He occupied, at the same time, all the following Chairs during this period: Medicine and Surgery; Clinical Medicine and Therapeutics; *Materia Medica*; Midwifery and Medical Jurisprudence. Mettauer was quite eccentric and always wore an enormous stovepipe hat, which he seldom took off. He left directions that he was to be buried in it, and it took an eight-foot coffin to contain the body and hat, together with some other things he directed to be buried with him.

Mettauer lived and worked in Worsham, Prince Edward County, Va., which is near Farmville, except for a short time in Norfolk, Va., and for another short period in Baltimore, in 1835, as Professor of Surgery in Washington Medical College.

He performed the first operation for cleft palate in Virginia in 1827. His article on staphylorrhaphy, in 1838, was one of the best up to that time,

## STORY OF PLASTIC SURGERY

and his success in this type of work was well-known. He described an operation for epispadias and hypospadias, and was interested in many other plastic problems. He was a remarkable surgeon and far ahead of his time; he devised and made many new surgical instruments; he used wire sutures in curing vesicovaginal fistulae 12 years before Sims reported the same method; he removed more than 800 cataracts during his career; he operated 400 times for stone, and over 200 times for the relief of strictures, besides performing all the other operations then known to surgery.

Doctor Pancoast was born in Burlington, New Jersey, and was graduated in Medicine from the University of Pennsylvania in 1828. He was Professor of Surgery at Jefferson Medical College ten years later, and Professor of Anatomy in 1847. He devised the plow and groove suture which he used in rhinoplastic operations, and reported, in 1868, an operation for exstrophy of the bladder, in which skin flaps from the abdominal wall and groin were utilized for the reconstruction. He also devised many new operations on the eye and in the general surgical field. He employed pedicled-flaps and also free skin grafts on several occasions, and was much interested in all plastic problems. He was a voluminous writer and a great teacher.

Doctor Warren was born in Boston. He was graduated in Medicine from Harvard University in 1832, and immediately went abroad to observe surgeons in London, Edinburgh and Paris. He was interested in plastic surgery, as was his father, John C. Warren. On his return to Boston, he reconstructed a nose in 1834, by the use of a forehead flap, which was the first nasal reconstruction performed in this country, and, in 1840, he reconstructed another nose by using a flap from the arm. In 1843, he published a method of closing congenital clefts of the hard and soft palate at the same time by the use of mucoperiosteal flaps, and reported 14 cases.

Warren also employed successfully free whole-thickness grafts in making repairs on eyelids and noses. He operated for syndactylism and did many other plastic reconstructions requiring tissue-shifting, as well as a great deal of general surgery. He was a distinguished surgeon and a voluminous writer.

Doctor Mütter was born in Richmond, Va., and graduated in Medicine at the University of Pennsylvania in 1831. He then went to Europe as surgeon on the Corvette Kensington, and while there attended various clinics and returned the following year. He devoted himself to surgery, and, in 1841, ten years after his graduation, was Professor of Surgery in Jefferson Medical College. He was especially interested in burn contractures and the innumerable subsequent deformities and devised new methods for their relief by means of pedicled-flaps. He was successful with the repair of congenital lip clefts. His remarks on scars, in general, and methods of handling them are well worth while reading to-day by anyone interested in the subject. He was an excellent surgeon and a great teacher but cared little for writing.

The discovery of anesthesia, both general and local, made possible the carrying out of procedures in plastic surgery with safety and comfort, which could never have been undertaken previously.

Following the epochal discoveries of Louis Pasteur (1822-1899), and Joseph Lister (1827-1912), antisepsis and asepsis had a most important bearing on plastic surgery, and made feasible operative procedures which would be impossible unless wound infection could be eliminated. It is interesting to note, however, that the majority of the principles of plastic surgery had been evolved and in many instances successfully carried out long before "listerism" was thought of.

Following the work of Pancost, Warren, Mütter and others, the use of pedicled-flaps became more common. The basic principles of the original Indian, Italian and French methods of flap-shifting were for the most part unchanged. However, it was not until the convincing papers of H. Maas (1842-1886), which appeared in 1884-1886, that widespread attention was given to the use of this method of tissue-shifting all over the body.

Then the progress of flap development was advanced by the "island-flap" method where the skin margins were completely severed and where the base tissues and included blood vessels and nerves formed the pedicle. This type of flap was devised and first employed by Robert Gersuny (1844-1924), of Teplitz, Bohemia, and was reported in 1887. In 1893, Theodore Dunham, of New York, first reported the successful use of the artery, with accompanying vessels and nerves, as the pedicle for a flap, and to him belongs the credit of devising this new conception.

Frantz Burian, of Prague, is said to have used the tubed-flap, in 1911, in the Balkan wars, but it was first reported by Filatof in 1916. It was independently developed by H. D. Gillies in 1917, at Sidcup, and to Gillies belongs the credit of showing its possibilities and in popularizing the procedure. All of the types of flaps mentioned, with many modifications, are now being constantly employed.

Before pedicled-flaps were employed in reconstructing noses, the Tile-maker caste in India are said to have successfully utilized free grafts of skin, including the subcutaneous fat, taken from the gluteal region, after it had been beaten with wooden slippers until a considerable amount of swelling had taken place. They used a secret cement for the adhesion, to which was ascribed special healing power. This was called the "Ancient Indian Method."

This is the earliest record of free whole-thickness grafting, although its successful application in total rhinoplasty must be doubted, as this is an accomplishment hardly possible even with modern surgical technic.

Hundreds of years passed, and up to the beginning of the nineteenth century, nothing of importance was done in regard to the transplantation of free grafts of skin. Then G. Baronio (1759-1811), the physiologist, carried out the following experiments in 1804.

In the first experiment, two whole-thickness pieces of skin of equal size and shape, without subcutaneous tissue, were cut from either side of the root of the tail of a sheep, and were immediately transferred to opposite sides.

The second experiment was similar except that the pieces of skin were kept detached for 18 minutes. In the third experiment, larger pieces were

used 12.5x7.5 cm. (5x3 inches) including the subcutaneous tissue and a bit of muscle. These pieces of tissue were left detached for one hour before being transferred to opposite sides. All of the grafts were successful, and the grafts bled when cut into, ten to 12 days after transplantation. Little notice was taken of these very significant experiments.

Attempting to revive the "Ancient Indian Method," Bünger, of Marburg, in 1823, reported the partly successful transplantation of a free whole-thickness skin graft from the thigh for the repair of a nasal defect, but von Graefe did not succeed with his attempts at rhinoplasty with free grafts, and Ph. v. Walther (1782-1849), Dieffenbach, and C. W. Wutzer (1789-1863) were no more successful.

The report of J.-L. Reverdin (1842-1929) to the Société Impériale de Chirurgie, in Paris, on December 8, 1869, of the hastening of the healing of granulating wounds by means of small, very thin, detached bits of transplanted skin, which he called "epidermic grafts," and the discussion of this paper one week later, was the spark which was needed to start the flame of interest in the subject of skin grafting throughout the world. In 1872, Reverdin admitted that his graft contained a portion of the corium, and, therefore, was not an epidermic graft.

L. X. E. L. Ollier (1830-1900), of Lyon, in 1872, successfully transplanted much larger films of skin (4, 6, and 8 cm. square) using the entire epidermis and a portion of the dermis.

At the Fifteenth Congress of the German Surgical Association, in 1886, Carl Thiersch (1822-1895) presented his perfected method of skin grafting, in which he covered the defects with large films of epidermis with a very thin portion of the dermis, but gave no credit to Ollier who had done the same thing 12 years previously.

Within the last few years, the Ollier-Thiersch type of graft has been cut much thicker, so as to include about one-half of the thickness of the corium and has been called the "split-graft" (Blair and Brown), the "razor-graft" (Gillies), the "midthickness graft," etc.

In order to obtain a more stable healing, investigators again began to try out the use of the whole-thickness of the skin and a number of successful results were reported. In 1875, John Reissberg Wolfe (1824-1904), of Glasgow, reported the successful plastic repair of a defect about the lower eyelid with a free whole-thickness graft 2.5x5 cm. (1x2 inches) from the arm. He is generally accredited with introducing this method. To Fedor Krause (1857-1937), of Altoona, however, is due the credit of bringing whole-thickness grafts into practical use. In 1893, at the Twenty-second Congress of the German Surgical Association, he reported his perfected technic and advised the use of the whole-thickness graft in all cases where the Ollier-Thiersch graft had been found lacking.

In looking about for a simpler technic for skin grafting which could be used without difficulty by almost anyone, J. S. Davis described, in 1914, what he called the "small deep graft," which was based on Reverdin's idea,

but instead of being the thinnest bit of superficial skin that could be cut, it included the full-thickness of the skin at its center, and this type of graft has turned out to be of great general value. Free skin grafts based on the original types and methods, either with or without changes in technic, are more universally used to-day than ever before.

As time went on, it was found that in the evolution of modern plastic surgery, the transplantation of tissues other than skin were required. These tissues were bone, cartilage, periosteum, fascia, fat, tendon, muscle, nerve, mucous membrane and cornea, and their importance in plastic surgery is becoming more and more apparent. The methods of their free transplantation were developed, for the most part, late in the nineteenth and in the beginning of the twentieth century.

In addition to the transplantation of the individual tissues mentioned, parts already formed have been transplanted. J. L. Joyce has replaced a missing thumb by transplanting the ring finger from the other hand. Fingers or portions of fingers have been replaced by toes by a number of surgeons, the latest case being reported by V. P. Blair and L. T. Byars. Fingers have also been used in reconstructing noses.

Deformities, such as congenital clefts of the lip and palate, syndactylyism, epispadias, hypospadias, congenital and traumatic scar contractures, hemangioma, lymphangioma, hypertrophied breasts, extensive moles, etc., etc., have always been of interest to the plastic surgeon. The story of the development of methods of treatment in each of these groups and of those who developed them is fascinating, but lack of time precludes their consideration here.

In the First World War, plastic reconstruction of wounded men in the belligerent countries abroad was confined to the face and jaws, and great hospitals were organized where faciomaxillary cases were segregated and cared for.

Later, in our own army, under Col. Vilray P. Blair, a division was formed whose work was similarly limited, and this was also called the Faciomaxillary Division, as in the British Army. The plastic work of the rest of the body, which is equally important, was not segregated but was undertaken as routine work by the general or orthopedic surgeons.

I urged, at that time, that the Division be expanded to include all cases requiring plastic reconstruction, but could not put it over, as there was no appreciation of the necessity of general plastic surgery by those with the power to act. I have again urged this expansion in the present emergency, and it seems probable that the suggestion may be carried out in the new tables of organization, which have been prepared in the program of Medical Preparedness, and that the Division will be called the Plastic and Faciomaxillary Division. Should this be done, and the division be properly developed and manned, it will add enormously to the efficiency of the care of patients with lesions requiring plastic surgery of the neck, trunk and extremities, as well as of the face and jaws.

## STORY OF PLASTIC SURGERY

In the present war, with its new type of bombing and machine-gun attack on civilians as well as soldiers, there will be great numbers of patients requiring the help of the plastic surgeon. It is reported that in England, as early as August, 1940, ten special centers had been established for the treatment of faciomaxillary and plastic cases, and that early transfer of these cases is particularly enjoined.

While no definite information is available from the Axis powers, doubtless arrangements have also been made by them for the prompt evacuation, by plane or other means, of the wounded requiring plastic work.

In the light of the rôle played by plastic surgery in mutilating wounds in the World War and in the present conflict, it seems evident that in civil life in this mechanized age with its speed and numerous accidents, that the close cooperation of trained plastic surgeons should be in order in the Accident Department as well as in the Surgical Service of every great hospital.

In bringing the subject up to date in the United States, it is interesting to note that less than 25 years ago there was no Division or Department exclusively devoted to plastic surgery in any medical school, hospital, or clinic in this country. As far as I can ascertain, the first effort in this direction was made by the speaker at the Johns Hopkins Hospital, and in a paper read before the Surgical Section of the American Medical Association in 1916, I advocated the formation of a separate Division of Plastic Surgery, and was thought "a little touched" by the heads of the surgical departments everywhere. This was the first of several papers on the same general subject, and I feel that they have borne fruit, as at the present time, in spite of bitter early opposition, there are well-organized Divisions or Departments of Plastic Surgery in the majority of up to date great medical schools, clinics and hospitals, and the care of patients requiring plastic and reconstructive surgery has, in consequence, been enormously improved.

There are two recognized organizations of plastic surgeons in the United States—The American Association of Oral and Plastic Surgeons, and the Society of Reconstructive and Plastic Surgeons. Both of these groups have one or two meetings each year in different cities, at which time operative clinics are observed, scientific papers presented and ideas are interchanged.

Through the efforts of Vilray P. Blair, an American Board of Plastic Surgery has been organized, which is made up of representatives of widely distributed groups interested in this special type of surgery. The Board is a subsidiary of the American Board of Surgery. Two types of certificates are issued by the Board: (1) Those covering plastic surgery of the general surgical field; and (2) those covering single surgical fields.\*

There was no recognition for plastic surgeons by the American College of Surgeons until recently, but now "Fellows," who are limiting their practice to plastic surgery, are so listed in the year book. Already, several

\* At a meeting of the Advisory Board for Medical Specialties of the American Medical Association on February 16, 1941, the American Board of Plastic Surgery was given the status of an independent board.

institutions have been approved by the Council of Medical Education and Hospitals of the A.M.A., as accepted in the training of interns and Fellows in plastic surgery.

Over 35 years ago, my friend, Doctor J. M. T. Finney, who knew of my interest in plastic and reconstructive surgery, suggested that I concentrate on this work. I took his advice, and my first paper on a subject dealing with plastic surgery was published in 1907. Since that time, I have been particularly interested in the ethical development of plastic and reconstructive surgery in this country, and it is very gratifying to think that possibly I have had something to do with placing this important surgical specialty upon its present status as a recognized subdivision of general surgery.

#### BIBLIOGRAPHY

##### APPENDED ARE SOME OF THE REFERENCES CONSULTED IN THE PREPARATION OF THIS PAPER

- Arnold, Howard Payson: Memoirs of J. Mason Warren, Boston, 1886.
- Baronio, G.: Degli Innesti Animali. Milan, 1804.
- Idem*: Über anamalische Plastik, Ubersetz. f. Bloch Halberstadt, 1819.
- Bhishagratna, K. K. L.: The Sushruta Samhitá. Calcutta, 1907. 3 vols.
- Blair, V. P., and Brown, J. B.: The Use and Uses of Large Split Skin Grafts of Intermediate Thickness. *Surg., Gynec., and Obstet.*, **49**, 82, 1929.
- Blair, V. P., and Byars, L. T.: Toe to Finger Transplant. Tr., South. Surg. Assn., **52**, 465, 1939.
- Breasted, J. H.: The Edwin Smith Surgical Papyrus. Univ. of Chicago Press, 1930.
- Buck, Albert H.: The Growth of Medicine from the Earliest Times to About 1800. Yale Univ. Press, New Haven, 1917.
- Bünger: Rhinoplasty from a Full-Thickness Skin Graft. *J. der Chirurgie und Augen-Heilkunde*. C. F. Gräfe und Ph. v. Walther, 1823, p. 569.
- Bussmaker et Daremberg: Oeuvres d'Oribase, etc. Paris. L'Imprimerie nationale, 1851-1876. 6 vols.
- Carpue, J. C.: An Account of Two Successful Operations for Restoring a Lost Nose from the Integuments of the Forehead. London. Longman, Hurst, Rees, Orme and Brown, 1816.
- Cordell, E. F.: The Medical Annals of Maryland. Baltimore, 1903.
- Coxe, J. R.: Writings of Hippocrates and Galen. Philadelphia, Lindsay & Blakiston, 1846.
- Cutter, Irving S.: Landmarks in Surgical Progress. *Intern. Abst. Surg.*, **51**, 275, October, 1930.
- Daremberg, Ch.: Oeuvres de Galien. Paris, 1854. 2 vols.
- Davis, J. S.: The Use of Small Deep Skin Grafts. *J.A.M.A.*, **63**, 985, September 19, 1914.
- Idem*: Plastic and Reconstructive Surgery. *J.A.M.A.*, **67**, 338, July 29, 1916.
- Idem*: The Division of Plastic Surgery: Its Organization; Its Needs; Its Field of Usefulness. *Tr. West. Surg. Assn.*, 1932, p. 209.
- Dawson, Warren R.: The Earliest Surgical Treatise. *Brit. Jour. Surg.*, **20**, 34-43, 1932-1933.
- Dieffenbach, J. F.: Mémoire et observations sur la restauration du nez. *Jour. compl. d. se méd.*, **39**, 162, 1831.
- Dorrance, George M.: The Operative Story of Cleft Palate. W. B. Saunders & Co., 1933.

## STORY OF PLASTIC SURGERY

- Dunham, Theodore: A Method for Obtaining a Skin Flap from the Scalp and a Permanent Buried Vascular Pedicle for Covering Defects of the Face. *ANNALS OF SURGERY*, **17**, 677, June, 1893.
- Esser, J. F. S.: Biological or Artery Flaps of the Face. *Institut Esser de Chirurgie Structive*, Monaco, 1933.
- Filatoff, W.: Plastie tige ronde. *Westnik oftalmol.*, 1917, Avril, Mai, Nos. 4, 5 (Russe).
- Idem*: Operations plastiques a tige ronde ambulante. *Presse Medicale*, **31**, 1061, December 19, 1923.
- Gersuny, R.: Plastischer Ersatz der Wangenschleimhaut (Island Flap). *Zentralbl. f. Chir.*, **14**, 706, September 17, 1887.
- Garrison, Fielding H.: An Introduction to the History of Medicine. Philadelphia, Saunders & Co., 1917.
- Gillies, H. D.: Plastic Surgery of the Face. London, Oxford Univ. Press, 1920.
- Idem*: Experiences with Tubed-Pedicle Flaps. *Surg., Gynec., and Obstet.*, **60**, 291, February 15, 1935.
- Graefe, C. F. v.: Rhinoplastic oder die Kunst, den Verlust der Nase organisch zu ersetzen, Berlin, 1818.
- Graham, Harvey: The Story of Surgery. New York, Doubleday, Doran & Co., 1939.
- Gurlt, E.: Geschichte der Chirurgie und ihrer Ausübung. Berlin, 1898. Verlag von August Hirschwald. 3 vols.
- Jee, B. S.: A Short History of Aryan Medical Science. Macmillan, 1896.
- Johnston, Geo. Ben: A Sketch of Dr. John Peter Mettauer of Va. Tr. Am. Surg. Assn., **23**, I, 1905.
- Joyce, J. L.: New Operation for Substitution of a Thumb. *Brit. Jour. Surg.*, **5**, 499, January, 1918.
- Kelly, H. A., and Burrage, Walter L.: American Medical Biographies. Baltimore, Norman Remington Co., 1920.
- Krause, F.: Über die Transplantation grosser ungestielter Hautlappen. *Verhandl. d. deutsch. Gesellsch f. Chir.*, **22**, 46, 1893.
- Lexer, E.: Die freien Transplantationen. Stuttgart, Ferdinand Enke, 1919.
- Idem*: Malformations, Injuries and Diseases of the Face and Plastic Operations. Von Bergman's System of Surgery. Chaps. X-XIII. New York, Lea Bros. & Co., 1904.
- Lisfranc, J.: Mémoire sur la rhynoplastie. *Mém. Acad. de méd.*, **2**, 145, 1833.
- Maas, H.: Über Plastik mit frischen gestielten Lappen aus entfernten Koerpertheilen. *Archiv. f. klin. Chir.*, **31**, 559, 1885.
- Idem*: Weitere Fälle von Plastik mit frischen gestielten Lappen aus entfernteren Koerpertheilen. *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 14th Kongress 1885, 447.
- Idem*: Weitere Fälle von Plastik mit frischen gestielten Lappen aus entfernteren Koerpertheilen. *Arch. f. klin. Chir.*, **33**, 323, 1886.
- Mettauer, J. P.: Staphylorrhaphy. *Am. Jour. Med. Sci.*, **21**, 309, February, 1838.
- Mütter, Thomas D.: Cases of Deformity from Burns Relieved by Operation. *Am. Jour. Med. Sci.*, **4**, (n.s.) 66, July, 1842.
- Neuhof, H.: The Transplantation of Tissues. New York, D. Appleton & Co., 1923.
- Ollier, L.: Greffes cutanées ou autoplastiques. *Bull. de l'Acad. de méd.*, Paris, **Sérié 243**, **2**, 1872.
- Pancoast, J.: Plastic Operations. *Am. Jour. Med. Sci.*, n.s., **4**, 337, October, 1842.
- Power, Sir D'Arcy: Some Early Surgical Cases. *The Edwin Smith Papyrus*. *Brit. Jour. Surg.*, **21**, I, July, 1933; *ibid.*, **22**, 385, January, 1934.
- Renouard, P. V.: History of Medicine from Its Origin to the 19th Century. Translated by C. G. Comegys. Philadelphia, J. B. Lippincott, 1856.
- Reverdin, J. L.: Greffe épidermique. *Bull. de la Soc. de Impériale de Chir.*, Paris, 2nd series, 493 and 511, December 8 and 15, 1869.
- Idem*: De la greffe épidermique. *Arch. gén. de méd.*, **19**, 276; 555; 703, 1872.

- Royle, J. F.: The Antiquity of Hindoo Medicine. London, 1837.
- Roux, J.-P.: Mémoires sur staphylorrhaphie, Paris, J.-S. Chaude, 1825, p. 84.
- Sen-Gupta, K. N. N.: The Ayurvedic System of Medicine. 1919, 3 vols.
- Spencer, W. G.: De medicina. English translation of Celsus in 3 vols. Harvard Univ. Press, 1938.
- Tagliacozzi, G.: De curtorum chirurgia per insitionem. Venice, 1597.
- Thiersch, C.: Über Hautverphlanzung. Verhandl. d. deutsch. Gesellsch. f. Chir., 15, 17, 1886.
- Warren, J. M.: Rhinoplastic Operation. Boston Med. Surg. Jour., 16, 69, 1837.
- Idem*: Rhinoplastic Operations with Some Remarks on Autoplasty Methods. Boston Med. Surg. Jour., 22, 264, 1840.
- Wolfe, J. R.: A New Method of Performing Plastic Operations. Brit. Med. Jour., 2, 360, September 18, 1875.
- Zeis, Eduard: Handbuch der plastischen Chirurgie, 1838.
- Idem*: Die Literature and Geschichte der plastischen Chirurgie, 1863.

## BLOOD AND BLOOD SUBSTITUTES IN THE TREATMENT AND PREVENTION OF SHOCK: WITH PARTICULAR REFERENCE TO THEIR USES IN WARFARE\*

ALFRED BLALOCK, M.D., AND M. F. MASON, PH.D.

NASHVILLE, TENN.

FROM THE DEPARTMENTS OF SURGERY AND BIOCHEMISTRY OF VANDERBILT UNIVERSITY, NASHVILLE, TENN.†

THE SUBJECT assigned to us in this symposium is that of the use of blood and blood substitutes in the treatment and prevention of shock. This is an important assignment because it is generally agreed that the single most effective method for combating shock lies in supplementing the reduced blood volume by the intravenous introduction of fluids, and it is a timely subject because of the increase in the number of the injured as a result of world warfare. It is a difficult subject, particularly at the moment, because of the rapid strides that are being made as a result of intensive and extensive investigations on methods for obtaining, preserving, transporting and administering blood or substitutes for blood.

It is to be understood that this communication deals, in the main, with wound shock (secondary or hematogenic shock) in which there is a decrease in the blood volume due to the loss of whole blood or plasma or both, and this loss may be local or general or both. The consequences of this reduction of blood volume are an inadequate venous return to the right heart, a decline in cardiac output, a fall in blood pressure, and stagnant anoxia, *i.e.*, peripheral circulatory failure. It has been our contention<sup>1a, 1b</sup> that the fluid loss in the early stages of peripheral circulatory failure is mainly local, at and near the site of injury, and that the general loss of plasma usually does not occur until after the reduced blood volume and pressure and the associated anoxia have resulted in a general increase in capillary permeability. Previous studies<sup>2</sup> demonstrated that a sustained decline in blood volume and blood pressure as a result of simple bleeding without associated trauma to tissues results in a general increase in capillary permeability with loss of fluid. A decline in blood pressure without a marked decrease in blood volume, such as occurs in reflex, primary or neurogenic shock does not result so readily in this general damage. The best means devised, thus far, for preventing or combating this general increase in capillary permeability in secondary shock consists of the introduction of adequate quantities of whole blood or plasma. These fluids should not be administered in fixed quantities but according to the needs of the patient. If a small quantity is

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

† Aided by a Grant from the Division of Medical Sciences of the Rockefeller Foundation.

ineffective, it does not follow necessarily that several times that amount may not result in permanent benefit.

Limiting our remarks, for the moment, to the use of whole blood and plasma, the problem is considerably more complicated in warfare than in the civilian practice of surgery. Present methods of warfare are resulting in the injury of many noncombatants and the treatment of these is not vastly different from that of peace-time accidents. Naturally, the larger volume of such injuries requires an increase in personnel, in equipment, and in available blood and plasma. The major difference in the preparation for the treatment of the combatants and noncombatants lies in the facts that the former are more likely to be away from the source of supply, and that continued enemy activity is more apt to interfere with prompt treatment. Distance from the source of supply of the whole blood and plasma introduces many perplexing problems, the greatest of which is the preservation of these fluids. When the distance is great, the use of whole blood, other than that obtained locally from the military personnel, has been considered unsafe and impracticable. Even the use of plasma presents certain problems, the greatest of which are the sterility of the solution and preservation without denaturation. These points will be considered in more detail subsequently.

The ideal treatment of shock consists of replacing fluid at the earliest possible moment in the form in which it has been lost. Unfortunately, this ideal is not obtainable under all circumstances, and the employment of less effective means of therapy may be necessary. Means by which the reduced blood volume may be supplemented, at least temporarily, and their limitations include the following:

#### THE EFFECTS OF INTRAVENOUS INJECTION OF VARIOUS FLUIDS UPON SHOCK

*Isotonic Solutions of Salt or Glucose.*—These are of much greater value in the prevention of than in the treatment of shock. Dehydration is one of the most frequent of the contributing causes of shock and the administration of one or both of these fluids is indicated. When the loss of blood in uncomplicated hemorrhage has been slight or moderate, a spontaneous increase in the blood volume occurs as a result of the passage of fluid from the tissue spaces into the blood stream. Tissue fluid must, therefore, be classed as a blood substitute, and this is supplemented by the passage of red blood corpuscles and plasma proteins from their reserve depots. The introduction of salt or glucose solutions in adequate quantities replaces the deficit in the extracellular fluids.

When the conditions are more extreme and there is an associated local or general gross damage to many capillaries, solutions of crystalloids cannot be considered correctly as substitutes for blood because they are lost from the blood stream rapidly and are ineffective in maintaining the blood volume and pressure. In fact, the intravenous injection of large quantities of solutions of crystalloids in the presence of gross capillary damage may actually result

## SHOCK TREATMENT

in harm rather than benefit. In association with Dr. J. W. Beard, and others,<sup>3a, 3b</sup> it was found, under these circumstances, that the administered crystalloid solutions wash protein out of the blood stream and that an accentuated hypoproteinemia results. Tissue edema rather than an increase in the blood volume occurs. The unfortunate situation that one encounters frequently during the intravenous administration of crystalloids is that the concentration of protein is decreasing while that of the red blood cells is increasing, and this is convincing evidence that plasma is being lost from the blood stream and that the blood volume is not being restored.

Somewhat similar statements may be made regarding the injection of *hypertonic solutions of crystalloids* in the treatment of patients with gross local or general damage to capillaries. A transient beneficial hydremia is followed by rapid escape from the blood stream of both fluid and protein causing tissue edema rather than a sustained increase of the blood volume.

The obvious conclusion is that solutions of crystalloids are not satisfactory and acceptable blood substitutes in the treatment of shock. Amberson<sup>4</sup> recently stated that the only effective blood substitutes are those which contain sufficient colloidal material to give a colloidal osmotic pressure approximating that of normal blood and that these are blood plasma or serum, Ringer-Locke solutions containing dissolved hemoglobin, and gum-saline.

*Gum acacia* probably ranks next to blood plasma or serum as the most successful substitute for whole blood. There is little doubt that it is less effective, and more dangerous than plasma or serum in the treatment of shock. Amberson<sup>4</sup> has enumerated the objectionable features encountered in the use of gum-saline. These are as follows: (1) The sedimentation rate of the red cells is greatly increased; (2) the red corpuscles are coated with gum, and the diffusion of oxygen is hindered; (3) the osmotic pressure is not maintained for much more than 48 hours since gum leaves the blood stream fairly rapidly; (4) gum is fixed in some of the tissues, particularly the liver and may remain there for years; (5) retention in the liver results in a diminution in the concentration of plasma proteins; and (6) there is considerable danger from antigenic action. These objections are not so serious that they prohibit the use of gum acacia if whole blood or plasma is not obtainable. On the other hand, we are inclined to agree with Phemister,<sup>5</sup> Trout,<sup>5</sup> and others that gum acacia should be employed only in case of dire emergency.

*Gelatin-saline* is only slightly superior to a colloid-free saline in its ability to restore the blood volume and there are many objections to its use. *Hemoglobin-Ringer* solution may serve a temporary purpose but hemoglobin leaves the blood stream rather quickly. The resulting hemoglobinuria may lead to renal complications due to deposition of hematin in the tubules unless the urine is kept alkaline. The situation here is similar to that encountered following a severe transfusion reaction associated with hemolysis and hemoglobinuria.

*Whole blood*, fresh or preserved, as might be anticipated, is a satisfactory

fluid for intravenous introduction in the treatment of shock. It is clear that it serves two purposes, restoration of erythrocytes and augmentation of the plasma protein concentration. The loss of red cells may or may not have occurred in shock and inasmuch as the fall in blood volume is related to plasma protein deficit rather than to anemia, the restoration of cells in any case is relatively of less importance and, indeed, may be ignored except in extreme instances of repeated hemorrhage. A considerable proportion of a given volume of whole blood, therefore, is utilized in ameliorating a circumstance which if it exists at all, is of secondary importance.

It is our impression, however, that the administration of large amounts of whole blood in the treatment of shock even when accompanied by hemoconcentration is not contraindicated. Observations by Wood and Blalock<sup>6</sup> show that the erythrocyte count in the circulation may be increased very significantly without causing detectable untoward symptoms providing the blood volume is maintained at essentially a normal level. On the other hand, in the presence of a decline in blood volume large increases in cell count and viscosity undoubtedly impose an additional burden upon the already impaired circulation.

*Liquid blood plasma and serum* will be considered in more detail because it is generally agreed that they are the most useful of all fluids in shock therapy whether the condition has been brought about by simple bleeding or other causes, and because their use in military zones is free of several complications which accompany the employment of whole blood transfusions. Although certain conditions arising from warfare have revived the interest in use of serum or plasma, the subject is not new. The earlier literature was reviewed by Amberson,<sup>4</sup> in 1937. He stated: "It is now widely recognized that due to its organic and colloidal constituents blood plasma or serum, when properly prepared, may replace a very considerable fraction of whole blood in the mammalian body, without disturbance of normal function. Richet and Brodin (1917) were able to get recovery, in dogs, after replacement of as much as 96 per cent of the normal blood by horse serum. Even better results were found by Richet, Brodin and Saint-Girons (1917) and Richet (1919) when plasma was used instead of serum. Couvreur and Clement (1919), however, could not save dogs with serum after hemorrhage. Other excellent results after replacement of blood by plasma or serum have been observed by Guthrie and Pike (1907), Mann (1918), Foster and Whipple (1922), Rossius (1925), Kallius (1929), Weech, Goetsch and Reeves (1933) and others." Other pertinent observations include those of Rous and Wilson,<sup>7</sup> in 1918. They noted experimentally when the hemoglobin is reduced by not more than three-fourths, the plasma without the erythrocytes being replaced, that there is no marked alteration in the appearance or behavior of the animal. They concluded that it is not essential to supply blood corpuscles in ordinary cases of acute hemorrhage. Johnson and Blalock<sup>8</sup> found that the loss of whole blood is tolerated better than is the loss of an equal volume of blood plasma. Beard and Blalock<sup>3</sup> noted

## SHOCK TREATMENT

that the intravenous injection of blood serum in conjunction with intestinal trauma resulted in less alterations in the various circulatory functions than the introduction of whole blood.

Bond and Wright,<sup>9</sup> and Mahoney<sup>10</sup> found that plasma and serum are effective in the treatment of hemorrhage and shock. More recently Levinson, and his associates,<sup>11</sup> have emphasized the fact that serum or plasma is effective in supplementing the blood volume following severe hemorrhage in which there was a marked reduction in red blood corpuscles. Further evidence as to the value of plasma and serum as blood substitutes is supplied by the studies of Carrel and Lindbergh<sup>12</sup> who, using aseptic technic, succeeded in maintaining life and promoting growth for extended periods of isolated organs which were perfused with serum.

Plasma or serum need not be typed prior to administration although it is advisable to pool various lots in order to suppress the iso-agglutinin activity. They may be preserved for considerable lengths of time (*vide infra*) and, when available may be given with no more delay than that encountered in the injection of saline or saline-glucose solutions.

In addition to these considerations, plasma or serum is distinctly valuable from the point of view of nutrition, the protein of these fluids being readily available for catabolism as a source of energy. Nitrogen balance may be maintained even in a starving animal by transfusion of adequate amounts of these fluids,<sup>13-16</sup> and is more effective than whole blood in this respect.

*Dried Plasma or Serum.*—Desiccated plasma or serum, when properly prepared, may be regenerated by solution in water or salt solution into their original liquid forms. The therapeutic advantages of their use in shock are precisely those of fresh, unaltered liquid plasma or serum, which have already been discussed. The advantages of this form of blood substitute distinct from therapeutic value, and the means of preparation and preservation will be referred to subsequently in the discussion of preservation of blood and plasma or serum.

In comparing the virtues of whole blood and plasma or serum in the treatment of shock, it is worth while to consider the following proposition: The circulating hemoglobin may be rapidly reduced to one-fourth of the normal level with comparative safety; however a loss of approximately one-half of the total blood volume is usually fatal to man or animal. The presence of one million erythrocytes per cubic millimeter of blood is easily sufficient to maintain life providing the total circulating fluid volume is normal or essentially so, hence, the most important element in replacement therapy consists of the introduction of plasma or serum into the circulation. Volume for volume plasma supplies approximately twice as much osmotically active protein as does whole blood, it is nutritionally more effective, it need not be typed, it is more easily administered, and finally, it is readily preservable in the liquid state for considerable periods, or, suitably prepared as a dry powder, it may be stored for any length of time desired. Preserved whole blood, on the other hand, has a limited life of from two to three weeks.

The disadvantages of plasma or serum comprise the additional technical difficulties in their preparation, and the necessity for obtaining a larger amount of blood from donors in order to supply a given quantity of these fluids.

A point about which there is some difference of opinion is whether the plasma or serum should be used in concentrated or unconcentrated form. It is likely that the choice should depend somewhat on the nature of the injury. If the plasma volume is markedly diminished and the tissues are dehydrated, the use of the unconcentrated form appears to be indicated. On the other hand, Bond and Wright,<sup>9</sup> and Best and Solandt<sup>17</sup> have employed the concentrated form with good results. The latter authors precede the introduction of concentrated serum by an injection of pituitrin.

Thus far in this discussion, plasma and serum have been considered as though they are identical, ignoring the difference imposed by the presence of fibrinogen and anticoagulant in the former. This is not an important difference from the therapeutic viewpoint. There is, however, some evidence that something happens to the blood in the process of clotting which increases the likelihood of unfavorable reactions on intravenous injection of the separated serum. Stevens and Lee,<sup>18</sup> Brodie,<sup>19</sup> and O'Connor<sup>20</sup> state that a vasoconstrictor substance results from the process of blood clotting and that this is absent in citrated plasma. The main disadvantage of plasma is that veils of fibrin may form in the fluid, sometimes amounting to a thick jell, although these are readily removed by filtration prior to administration.

Opinion is somewhat divided as to the choice of plasma or serum. Levinson and his associates<sup>11</sup> prefer serum; Strumia, and his coworkers<sup>21, 22</sup> prefer plasma, while Best and Solandt<sup>23</sup> state that either is satisfactory. The latter authors stated: "We wish again to emphasize the point that plasma and serum free from reaction-producing substances are physiologically and therapeutically identical and may be used interchangeably. It will be regrettable if discussion of the relative merits of these two materials should in any way impede their production or inhibit their use under appropriate conditions." The extensive use of plasma is due at least partially to the fact that unclotted blood in blood banks may be converted into plasma after its age makes it advisable to use as whole blood. It is our impression that the use of plasma is slightly safer than that of serum.

#### COLLECTION, PRESERVATION, TRANSPORT AND DISPENSATION OF WHOLE BLOOD, PLASMA AND/OR SERUM

Collection of considerable quantities of blood such as are required during the active phases of war is a quite different problem from peace-time provision of blood in civilian hospitals, and requires extensive donor organization. Detailed comment upon this socio-economic administrative problem is outside the province of this symposium. Suffice it to say that whatever the type of organization is adopted, large numbers of typed donors are required, particularly those of the universal type. The use to which the organization is put

## SHOCK TREATMENT

is another matter and upon this a few brief statements might be made respecting the authors' point of view.

For most efficient practice it would appear best to have all transfusions in all areas made with preserved blood or blood substitutes when these are available. To meet acute emergencies during which these products are unavailable, typed military personnel or preferably local civilian universal type donors should be available to supply blood for immediate transfusion. The large effective donor organizations should be in centers where preserved blood and plasma are prepared for subsequent transport to areas where they are needed. The smaller civilian donor organization thus would be called upon only in combat emergency, or to supplement the blood supplied by the larger centers should that become inadequate for the accumulation of sufficient stores.

It is clear that these organizations would function most efficiently as a steady source of blood for these preparations, and in the large centers great stores, particularly of plasma, liquid or dry, could be accumulated. In this way a considerable economy of blood is achieved as stored whole blood becoming over-aged may be reclaimed for its plasma. It would appear that the German Army plan of preserving whole blood only from universal donors is desirable. Plasma, of course, may be prepared and dispensed without regard to typing as long as pooled lots are employed.

### (1) WHOLE BLOOD

*Collection.*—Whole blood collected from suitable donors may be employed as follows: (a) For immediate transfusion; (b) preserved for subsequent transfusion; (c) the plasma separated and preserved as liquid plasma or converted to dry plasma. Preserved blood, if not used for transfusion within certain limits of time, may be reclaimed for its plasma which, in turn, may be preserved or converted to dry plasma. On the other hand, the preliminary observations of Strumia<sup>5</sup> indicate that dried plasma should be prepared from blood plasma that has not been kept in the liquid state for more than two days. It is generally agreed that sodium citrate is the anticoagulant of choice in the collection of whole blood.

Fresh whole blood transfusion is a well-established procedure and need not be commented upon in detail. Under conditions of warfare in which organization may or may not be disrupted, it would seem desirable to adopt for collection a standard equipment and procedure characterized by simplicity and safety even at considerable additional expense. The Baxter system of vacuum bottles is a good example of standardized equipment and technic suitable for manipulation under almost any conditions. Such a system permits relatively unskilled personnel to collect blood from donors. In acute emergencies, when preserved blood or blood substitutes, or standard equipment is unavailable, some improvisations in technic might have to be introduced. The objection to the vacuum bottle system when this is necessary

is the additional load upon transport in keeping the requisite equipment with a given unit.

In collecting whole blood from large donor organizations for preservation or for conversion of the plasma, standardized equipment is, again, desirable. A vacuum bottle system has the advantages of ease of handling with minimum opportunity for contamination. This is particularly important in the preparation of liquid plasma which is to be preserved for a long time. The collected blood should be typed, and the Wassermann reaction tested. In respect to the latter, the Kahn test might be preferable, inasmuch as the combination of a negative Wassermann and positive Kahn test is encountered more frequently than is the reverse of this.

*Preservation.*—Much information respecting the problem of preservation of whole blood is to be found in recent papers by DeGowin, Harris and Plass,<sup>24</sup> Scudder, Drew, Corcoran and Bull,<sup>25</sup> Bull and Drew,<sup>26</sup> and many others.

It has been shown that blood should be collected in a cold container, that it should be traumatized as little as possible, that it should be stored at approximately 4° C., and should not be brought to body temperature before being given to the patient.<sup>27</sup> The two most important changes occurring in stored blood are diffusion of potassium from the cells into surrounding plasma, and hemolysis, the former preceding the latter. Other changes include the destruction of white blood cells, and platelets and a decrease in prothrombin. Preservatives may alter the time at which hemolysis begins and the rate at which it proceeds; for example, the addition of large amounts of glucose solution as advocated by Rous and Turner<sup>28</sup>; however, the same end may be achieved by increasing the glucose concentration without excessive dilution.<sup>24</sup> Under optimum conditions whole blood may be preserved satisfactorily without serious hemolysis for a month, but hemolysis sufficient to render use of the blood inadvisable may be encountered any time after the first few days. The diffusion of potassium into the plasma is apparently not of grave significance providing the blood is administered slowly to the patient. It does, however, indicate a fundamental alteration in the permeability of the red cell to basic cations, and this appears to be related to a diminution in capacity for respiration by the cell, although the capacity for oxygen transport is unchanged.<sup>29</sup> The relation of these findings to the subsequent fate of these cells following reinjection is not as yet clear. In the case of preserving blood which may later be reclaimed for plasma, a container which allows only a small surface contact between plasma and the sedimented cells serves to cut down the diffusion of potassium into the supernatant plasma. In any event preserved blood not over two weeks of age is usually as effective as fresh blood in the treatment of shock.

The alteration in white cells, platelets and prothrombin appear to be unimportant, but even though blood has considerable antiseptic powers, maintenance of asepsis in preserving blood is even more important than in per-

## SHOCK TREATMENT

forming fresh whole blood transfusion. Vacuum bottles are almost ideal in this respect.

*Transport.*—The preliminary observations of DeGowin and Plass<sup>5</sup> indicate that transportation of whole blood by various conveyances may be undertaken provided certain precautions are observed to prevent trauma or damage to the blood. These observations have not as yet been published. Liquid plasma or dried plasma, however, present far simpler problems in the matter of transport.

*Dispensation.*—This is a well-established procedure. In the case of preserved blood, observation of conservative age-limits, discard of frankly hemolyzed preparations, filtration, and administration without previous warming will eliminate most untoward reactions.

The use of whole blood from blood banks is certainly a practical means of treating injuries among the civilian population in time of war, and it will probably also be a feasible therapeutic agent in some of the larger army hospitals. There remains, however, the fact that the exigencies of warfare render plasma a more suitable fluid, all factors being considered.

### (2) PLASMA

Greater emphasis will be placed upon problems related to plasma than to whole blood in this symposium because information regarding them is less well-known and because plasma in a suitable form may be more readily available under combat conditions.

*Collection.*—Plasma, for subsequent transfusion either before or after preservation, may be separated from whole blood collected for that purpose alone, or from preserved whole blood which has passed the age limit for safe use. There are a good many controversial points about the collection of plasma yet to be solved; however, it is generally agreed that rigid asepsis is imperative. There is no doubt that this may be achieved best by use of vacuum bottles both for the collection of the original whole blood and as a container for the separated plasma. As stated previously, the vacuum bottle system is expensive, but this is probably justifiable in the treatment of war injuries. By the use of such a system, Elliott, Busby and Tatum<sup>30</sup> demonstrated no organisms on culture of 150 specimens of plasma, some of which had been stored at room temperature for as long as 18 months. From the standpoint of efficiency, it would appear desirable to employ the same "system" of apparatus and technic in collection of plasma as that used for whole blood.

Two methods may be employed for separation of cells from plasma, spontaneous sedimentation and centrifugation. The former yields a volume of plasma equal to approximately one-third that of the original whole blood-citrate mixture, whereas after centrifugation the volume of plasma obtained is usually somewhat greater than one-half the original volume. Sturgis<sup>5</sup> prefers spontaneous sedimentation despite the smaller yield because (a) less special apparatus is required; (b) heating and trauma of the blood

in connection with centrifugation are avoided, thus reducing hemolysis; and (c) the fewer manipulations reduce the chances of bacterial contamination. He suggests that the plasma be separated from the cells after 48 hours' spontaneous sedimentation at 4° C.

If centrifugation is employed, Strumia<sup>5</sup> advises chilling the interior of the centrifuge with dry ice. Elliott, and his associates<sup>30</sup> recommend that the centrifuged mixture be placed in the refrigerator for 12 hours before aspirating the plasma in order to further reduce its cell count. Brief, cold centrifugation after spontaneous sedimentation does not appear to promote hemolysis if the red corpuscles and plasma are not mixed again prior to centrifugation.

Gross precipitates are apt to form in plasma after its separation from cells. Elliott, Busby and Tatum<sup>30</sup> found that the quantity of these was reduced by using fasting donors, by separating the plasma from stored blood rather than fresh blood, by dilution of the separated plasma to approximately the original blood volume with physiologic saline containing glucose, and by the addition of "merthiolate" to a final concentration of 1:10,000. In order to get rid of further precipitates or the usual fibrin "veil" which forms in aging plasma, it should be filtered at the time of transfusion.

The collected plasma should not show frank evidence of hemolysis; however, a greater degree of hemolysis may be tolerated if the plasma is to be used for immediate transfusion than if it is to be preserved. Unless plasma is used for immediate transfusion into a recipient of the same group as the donor, lots of plasmata should be pooled to suppress the activity of the iso-agglutinins.

The methods employed by Scudder<sup>5</sup> in his wide experience with the Blood Betterment Association in collection of blood for the British, merit a detailed description: "Blood is drawn from voluntary donors into 235 MI. centrifuge tubes; it is chilled in the refrigerator and placed in a chilled centrifuge (this is done by a cone holding dry ice, thereby obviating the expense of a cold centrifuge); the plasma is withdrawn by suction the next morning into a flask in which various plasmata are mixed. The bacteriologic study is immediately instituted, and should the report come back after 72 hours that the plasma is sterile, both as to aerobic and anaerobic tests, we then siphon off 500 cc. into Baxter plasmavacs of the 1,000 cc. variety. These flasks already have in them 500 cc. of physiologic salt solution. It is this mixture of plasma that we are sending to England." Satisfactory results have followed the use of plasma prepared in this manner. It should be stated, however, that Scudder<sup>5</sup> regards this as a makeshift procedure and is of the opinion that dried plasma is the answer to the problem.

*Preservation.*—Plasma may be preserved in one of three forms: (a) Liquid plasma; (b) dried plasma; and (c) concentrated liquid plasma. To date there seems little reason for exploiting the latter preparation as such, as it can be so readily prepared from dried plasma.

The preservation of *liquid plasma* by addition of "merthiolate" in a final concentration of 1:10,000 has been advocated by Strumia,<sup>5</sup> Elliott,<sup>30</sup> and

## SHOCK TREATMENT

others; however, preliminary observations by Sturgis,<sup>5</sup> and by Scudder<sup>5</sup> indicate that merthiolate is not a reliable preservative for plasma which is kept at room temperature.

It has been shown that one is warranted in using sterile plasma which has been kept in a refrigerator for a number of weeks, but the evidence is less certain respecting plasma stored at room temperature. Admitting that refrigeration is preferable, Elliott, Busby and Tatum<sup>30</sup> administered 53 samples of plasma which had stood at room temperature for from one to 270 days, some of which had been transported by various conveyances for as much as 17,000 miles without encountering any untoward reaction. The preliminary observations of Sturgis,<sup>5</sup> and Scudder<sup>5</sup> are not so encouraging. The latter author<sup>31</sup> stated recently that the electrophoretic pattern of unrefrigerated stored plasma is not normal. Presumably some sort of gradual denaturation takes place in liquid plasma not kept at low temperature, although the extent of this, and the degree to which it renders the plasma unsuitable for transfusion has not been clearly defined. If the preservation of unrefrigerated plasma for indefinite periods becomes feasible, it will greatly reduce the necessity for dried plasma preparations.

Intensive study of *dried plasma* has been instituted recently in order to obtain a plasma product suitable for intravenous injection after long storage periods at uncontrolled temperatures. The available evidence indicates that desiccated plasma protected from moisture in a sealed container is suitable in this respect, making it a highly desirable product for use under conditions attending military operations in spite of the increased difficulty and cost of its preparation. It may be pertinent to remark here that the marketing of either liquid or dried plasma by commercial houses at a reasonable price is excluded by donor costs. It is only through agencies having volunteer donors that they may be supplied at a cost which is not prohibitive.

Many problems respecting the preservation of plasma by dehydration remain to be clarified, including (a) most economical means of preparation; (b) kind of, and conditions obtaining in the container of the dried product; (c) the need for Wassermann testing of donors, *i.e.*, the survival of spirochetes in the dried product; and (d) means of sterilizing the dried plasma so that previous manipulations need not be aseptic. These and many others are the subject of contemporary investigation. In respect to *methods* it might be apropos to briefly summarize the present position.

### SUMMARY OF PRESENT METHODS TO PRESERVE DESICCATED PLASMA

Irrespective of what methods of desiccation are employed, the resulting product must be rapidly regenerable as a sterile protein solution whose original colloidal characteristics have not been materially altered. Inasmuch as in treating shock the primary aim is restoration of blood volume, preservation of the more labile components of plasma such as prothrombin, complement, *etc.*, is of secondary importance, although in the case of certain methods, notably those involving vacuum sublimation, these are unaffected.

Methods of producing such dried protein material may be roughly divided into three categories or combinations of these: (a) Simple evaporation; (b) vacuum desiccation;

and (c) dehydration without denaturation by organic solvents. Salt precipitations, etc., may be involved in any of these processes. To date, the removal of water from native plasma or serum by vacuum processes appears to have been thoroughly studied. The earlier literature on this and upon certain other procedures has been summarized by Elser, Thomas and Steffen,<sup>32</sup> and by Flosdorff and Mudd.<sup>33</sup>

Vacuum sublimation of vapor from frozen plasma or serum, first described by Shackell,<sup>34</sup> appears to produce an almost ideal dried product. When the volumes of plasma dried are more than a few cubic centimeters, the volumes of vapor at the pressure of the system are so enormous as to demand an especially large pump capacity or installation of some particularly efficient means of removing the vapor within the system, thus lessening the load on the pump.

Several processes have recently been described in which the principle of vacuum sublimation is utilized, the plasma being either prefrozen, or frozen, by the heat loss by evaporation in the early stages of the process ("snap-freezing"), and the frozen state is thus maintained until dehydration is nearly completed without additional chilling; indeed, heat may be applied with advantage to prevent too great a fall in the temperature and, hence, the vapor pressure of the subliming solid:

(1) The "Lyophile Process," of Flosdorff and Mudd,<sup>35</sup> is an improvement of similar procedures of antecedent workers. (See also references 32 and 35). In this method the vapor is removed within the system by a condenser chilled with a solid CO<sub>2</sub>-organic solvent mixture.

(2) The "Cryochem Process" (Flosdorff and Mudd<sup>36</sup>) employs anhydrous calcium sulphate to remove the vapor within the system by formation of the regenerable hemihydrate. Various chemical desiccants have been used by other investigators for the same purpose, including phosphorus pentoxide and sulphuric acid.

(3) The "Adtevac Process" (Hill and Pfeiffer<sup>37</sup>) utilizes chilled silica gel to adsorb the vapor in the system. The anhydrous gel may be readily regenerated for further use.

(4) The "Desivac Process" (Flosdorff, Stokes and Mudd<sup>38</sup>) permits the vapor to flow directly into the oil of a high vacuum pump, the oil in turn circulating through a continuously operating centrifuge which separates and removes the aqueous phase. Presumably the pump capacity is relatively large in order to remove the volume of vapor which is very great in spite of the fact that the operating pressure is somewhat higher than that of the other processes.

In all of these and other similar procedures the sterile plasma may be placed in the container from which it ultimately is to be dispensed, and attached to a manifold of the vacuum apparatus, or, after loose plugging, placed within the apparatus. In this way sepsis as a result of multiple transfer is avoided, and in the former procedure the container may be sealed *in vacuo* at the completion of the process before removal from the manifold. The dry product has a porous structure of considerable bulk and surface which readily goes into solution upon admission of a suitable quantity of sterile distilled water into the container. For this purpose and to facilitate dispensation various types of vaccine bottle stoppers have been employed, connection to the vacuum apparatus being made through these or by glass side-arms which may be sealed off separately with a blow torch.

The rate at which plasma can be desiccated by these vacuum sublimation procedures is a function largely of the size of the apparatus, *i.e.*, the number of vessels accommodated by the manifolds, condenser or adsorbent, and pump capacity. "Desivac" apparatus suitable for dehydration of 600 liters of plasma per week is now available.<sup>39</sup> Several hours, in any event, are required for the vapor transfer, and the apparatus required is rather expensive. The moisture content of the final product of these various products is usually 0.3 per cent, and may be reduced to a mere trace. An excellent discussion of vacuum sublimation is to be found in a recent paper of Greaves and Adair.<sup>35</sup>

In addition to the vacuum sublimation procedures, three other methods for plasma dehydration will be mentioned.

(1) Simple vacuum distillation may be employed to desiccate plasma as described

## SHOCK TREATMENT

recently by Edwards, Kay and Davie,<sup>40</sup> and Harper, Essex and Osterberg.<sup>41</sup> The product from these and similar processes usually is a hard, slowly soluble, scaly mass which must be ground before readily going into solution, although the product of Harper, Essex and Osterberg is stated to be flaky and easily soluble. The avoidance of contamination and the prevention of denaturation are difficult problems when this method is used.

(2) Plasma may also be readily concentrated or dried by evaporation in a current of air from the fluid contained in collodion bags (Thalhimer<sup>42</sup>). The resulting product, in our experience, does not easily go back into solution without preliminary pulverization.

(3) Labile proteins may be dehydrated without denaturation, by brief precipitation at low temperature from organic solvents, such as acetone ethyl and methyl alcohol.<sup>43, 44, 45, 46</sup> The excess solvent is readily removed *in vacuo* leaving a powder or porous cake of protein which may be quickly reconstituted in its original form by addition of water and the salts removed by the process providing the precipitation process has been carefully controlled. We are unaware of any reports dealing with this procedure for preparation of dried human plasma or serum for subsequent transfusion, although it is being employed in the preparation of heterologous plasma fractions prepared experimentally for this purpose by Cohn, and his associates.<sup>5</sup> This method, providing it can be suitably controlled, should, in the opinion of the authors, afford the cheapest and most rapid means of preparing large amounts of plasma or serum powder. Its subsequent storage *in vacuo*, the requirement of saline or Ringer's solution for regeneration rather than distilled water, and the problem of maintenance of asepsis necessary only in the latter stages of the process, should hardly overweigh the advantages this approach would, superficially, appear to possess. A great many investigators are now engaged in the study of the problem of dried plasma preparations and undoubtedly rapid advances will be made.

*Transport.*—The method of transport of liquid plasma will depend to a considerable extent upon the ultimate findings in respect to its preservability under conditions of uncontrolled temperature. It would appear desirable that it be transported in the container from which it is to be dispensed, particularly when used in areas of military operation. It should be considered, that when a liter of liquid plasma is transported, approximately 950 Gm. of unnecessary water is carried along with the 80 Gm. of essential protein. This is not a trivial matter when air transport to distant scenes of operation is involved.

Once it is sealed in a suitable container, dried plasma may be transported without special precautions in respect to temperature control. As it is desirable, ordinarily, that it be shipped in the container from which it is to be dispensed, it is clear that the mass, but not the bulk, is reduced in comparison to transport of an equivalent amount of liquid plasma. For long distance air transport, shipping in fully packed containers might be advisable. If containers of water for resolution of the dried plasma must be shipped with it, the load upon transport is even greater than that imposed by liquid plasma.

*Dispensation.*—The dispensation of liquid plasma is an even simpler procedure than that for whole blood, and, when available, may be administered with no greater delay or facilities than in the case of injection of saline or glucose solution. It is, however, usually advisable to filter liquid plasma just prior to administration in order to remove any precipitate or fibrin veil which may have formed.

The dispensation of dried plasma involves merely one preliminary step—

that of dissolving the product in an appropriate quantity of distilled water, which either must accompany the dried plasma or be available at the site of the transfusion. This constitutes a real difficulty under field conditions, and it is because of this that the Medical Corps of the British Army prefers the liquid form. In a recent communication from Dr. John Fulton it is stated that for immediate transfusion following the chaos of bombing casualties a liquid plasma or serum has decided advantages. When properly prepared, the plasma powder dissolves within a minute or two. One of the advantages of dried plasma is that it may be reconstituted in a small volume of water if so desired, yielding a concentrated plasma which may be especially desirable in certain instances.<sup>9, 17</sup> When the dried plasma is stored in a vacuum bottle, equipped with a readily punctured rubber vaccine cap, reconstitution is particularly simple, the requisite water being introduced by means of a syringe and needle.

### (3) SERUM

The problems encountered in respect to serum are identical with those of plasma except in relation to collection, and in the decreased fibrin with "veil" formation during storage of the liquid product. Inasmuch as the authors do not anticipate that serum shall be shown to have any advantages justifying its use *rather* than plasma, further consideration of this fluid will be omitted.

### (4) ANIMAL PLASMA

An almost infinite supply of plasma would be available from lower animals could this be so modified as to be suitable for intravenous injection in man. Indeed, single transfusions of native animal plasma are often tolerated without ill effects<sup>47, 16</sup> although the procedure can, by no means, be considered a safe one. Contemporary attempts to modify animal plasma by Cohn,<sup>45</sup> and the observations of Wangensteen,<sup>16</sup> and of others in regard to this fundamental problem are encouraging and may possibly lead to dramatic advances in the field of plasma therapy.

### SUMMARY

In the treatment of traumatic shock the primary objective is the restoration of a blood volume which has been reduced in consequence of hemorrhage, loss of plasma locally at the site of injury, or generally as a result of increased capillary permeability. Infusion of crystalloid solutions only transiently increases the blood volume and may, eventually, still further reduce it. Only whole blood or plasma may safely, effectively, and permanently restore the volume of the circulation, and of these plasma is preferable because a unit volume supplies more osmotically active protein than does whole blood. The latter, usually, is essential only in the presence of profound anemia.

The more frequent use of transfusions of whole blood and plasma has resulted in improved treatment of injuries encountered in civil life. Valuable time, in emergencies, is saved by having preserved whole blood from universal donors, and plasma, which need not be typed, available in blood banks.

The problems related to the collection, preservation, transport, and dis-

## SHOCK TREATMENT

pensation of whole blood and plasma have been discussed with special consideration of these in respect to military operations. The limitations of whole blood are accentuated under conditions of warfare, and the more readily preservable plasma is better adapted to cope with these complications. Particularly this is true of dried plasma which may be preserved indefinitely at uncontrolled temperatures. The length of time that sterile liquid plasma may be safely kept unrefrigerated is not yet satisfactorily established, and may be limited. In civil life dried plasma can be made available in communities remote from blood banks, or where direct whole blood transfusion is inconvenient or impractical. Dried plasma, however, has certain disadvantages both in civil and military surgery. Its preparation is expensive; sterile distilled water must be available where it is used or must accompany it; and some time, usually only a few minutes, is required for it to go into solution. This constitutes, however, a valid objection to its use in advanced military zones, since the liquid form may be administered with less delay and less equipment. Nevertheless, the dried form will remain superior to liquid plasma, all factors considered, until the problem of permanent preservation of the latter is solved.

Preliminary investigations related to the modification of animal plasma so that it may be suitable for intravenous injection are encouraging but have not yet progressed beyond an experimental stage.

It is our impression that the program of medical preparedness should include the organization of a number of well-equipped units in various cities throughout the country for the collection and preservation of whole blood and plasma. Emphasis should be placed upon the development of more efficient and less expensive means of preparing dried plasma, upon improving the preservation of liquid plasma; and, possibly, whole blood, and upon the development of animal plasma, or other protein substitutes for these. Even though the unhappy necessity of actively operating these centers for taking care of military casualties does not arise, the resulting improvement in availability of blood and plasma will result in a marked advance in the prompt and adequate treatment of shock in the civil practice of surgery.

## BIBLIOGRAPHY

- <sup>1a</sup> Blalock, Alfred: Experimental Shock. The Cause of the Low Blood Pressure Produced by Muscle Injury. *Arch. Surg.*, **20**, 959, 1930.
- <sup>1b</sup> Blalock, Alfred: Principles of Surgical Care. Shock and Other Problems. St Louis, C. V. Mosby Company, 1940.
- <sup>2</sup> Blalock, Alfred: Shock. Further Studies with Particular Reference to the Effects of Hemorrhage. *Arch. Surg.*, **29**, 837, 1934.
- <sup>3a</sup> Beard, J. W., Blalock, A., et al.: Intravenous Injections. *Jour. Clin. Invest.*, **11**, 249-325, 1932.
- <sup>3b</sup> Minot, A. S., and Blalock, A.: Plasma Loss in Severe Dehydration, Shock and Other Conditions as Affected by Therapy. *ANNALS OF SURGERY*, **112**, 557, 1940.
- <sup>4</sup> Amberson, W. R.: Blood Substitutes. *Biol. Rev.*, **12**, 48, 1937.
- <sup>5</sup> Personal communication, 1940.
- <sup>6</sup> Wood, G. O., and Blalock, A.: A Study of the Effects of Uncomplicated Hemocon-

- centration (Erythrocytosis), with Particular Reference to Shock. *Arch. Surg.* In Press.
- <sup>7</sup> Rous, P., and Wilson, G. W.: Fluid Substitutes for Transfusion After Hemorrhage. *J.A.M.A.*, **70**, 219, 1918.
- <sup>8</sup> Johnson, G. S., and Blalock, A.: Experimental Shock. A Study of the Effects of the Loss of Whole Blood, of Blood Plasma and of Red Blood Cells. *Arch. Surg.*, **22**, 626, 1931.
- <sup>9</sup> Bond, D. D., and Wright, D. G.: Treatment of Hemorrhage and Traumatic Shock by Intravenous Use of Lyophile Serum. *ANNALS OF SURGERY*, **107**, 500, 1938.
- <sup>10</sup> Mahoney, E. B.: Study of Experimental and Clinical Shock with Special Reference to Its Treatment by Intravenous Injection of Preserved Plasma. *ANNALS OF SURGERY*, **108**, 178, 1938.
- <sup>11</sup> Levinson, S. O., Neuvelt, F., and Necheles, H.: Human Serum as a Blood Substitute. *J.A.M.A.*, **114**, 455, 1940.
- <sup>12</sup> Carrel, A., and Lindbergh, C. A.: The Culture of Whole Organs. *Science (n.s.)*, **81**, 621, 1935.
- <sup>13</sup> Holman, R. L., Mahoney, E. B., and Whipple, G. H.: Blood Plasma Protein Given by Vein Utilized in Body Metabolism. II. A Dynamic Equilibrium Between Plasma and Tissue Proteins. *Jour. Exp. Med.*, **59**, 269, 1934.
- <sup>14</sup> Pommerenke, W. T., Slavin, H. B., Kariher, D. H., and Whipple, G. H.: Dog Plasma Protein Given by Vein Utilized in Body Metabolism of Dog. Horse Plasma and Dog Hemoglobin Not Similarly Utilized. *Jour. Exp. Med.*, **61**, 283, 1935.
- <sup>15</sup> Daft, F. S., Robscheit-Robbins, F. S., and Whipple, G. H.: Plasma Protein Given by Vein and Its Influence Upon Body Metabolism. *Jour. Biol. Chem.*, **123**, 87, 1938.
- <sup>16</sup> Wangensteen, O. H., Hall, H., Kremen, A., and Stevens, B.: Intravenous Administration of Bovine and Human Plasma to Man: Proof of Utilization. *Proc. Soc. Exp. Biol. and Med.*, **43**, 616, 1940.
- <sup>17</sup> Best, C. H., and Solandt, D. Y.: Concentrated Serum in Treatment of Traumatic and Histamine Shock in Experimental Animals. *Brit. Med. Jour.*, **1**, 799, 1940.
- <sup>18</sup> Stevens, L. T., and Lee, F. S.: Quoted by Amberson.<sup>4</sup>
- <sup>19</sup> Brodie, T. G.: The Perfusion of Surviving Organs. *Jour. Physiol.*, **29**, 266, 1903.
- <sup>20</sup> O'Connor, J. M.: Über den Adrenalingehalt des Blutes. *Arch. exp. Path. u. Pharmak.*, **67**, 195, 1912.
- <sup>21</sup> Strumia, M. M., Wagner, J. A., and Monaghan, J. F.: The Use of Citrated Plasma in the Treatment of Secondary Shock. *J.A.M.A.*, **114**, 1337, 1940.
- <sup>22</sup> Strumia, M. M., Wagner, J. A., and Monaghan, J. F.: The Intravenous Use of Serum and Plasma, Fresh and Preserved. *ANNALS OF SURGERY*, **111**, 623, 1940.
- <sup>23</sup> Best, C. H., and Solandt, D. Y.: Use of Plasma or Serum as a Substitute for Whole Blood. *Brit. Med. Jour.*, **2**, 116, 1940.
- <sup>24</sup> DeGowin, E. L., Harris, J. E., and Plass, E. D.: Studies on Preserved Human Blood. I. Various Factors Influencing Hemolysis. *J.A.M.A.*, **114**, 850, 1940.
- <sup>25</sup> Scudder, J., Drew, C. R., Corcoran, D. R., and Bull, D. C.: Studies in Blood Preservation. *J.A.M.A.*, **112**, 2263, 1939.
- <sup>26</sup> Bull, D. C., and Drew, C. R.: The Preservation of Blood. *ANNALS OF SURGERY*, **112**, 498, 1940.
- <sup>27</sup> DeGowin, E. L., Hardin, R. C., and Swanson, L. W.: Studies on Preserved Human Blood. IV. Transfusion of Cold Blood into Man. *J.A.M.A.*, **114**, 859, 1940.
- <sup>28</sup> Rous, P., and Turner, J. R.: The Preservation of Living Red Blood Cells *in Vitro*. Methods of Preservation. *Jour. Exp. Med.*, **23**, 219, 1916.
- <sup>29</sup> Mason, M. F., and Blalock, A.: Unpublished observations, 1940.
- <sup>30</sup> Elliott, J., Busby, G. F., and Tatum, W. L.: Some Factors and Observations on Preparation and Preservation of Dilute Plasma. *J.A.M.A.*, **115**, 1006, 1940.
- <sup>31</sup> Scudder, John: Studies in Blood Preservation. The Stability of Plasma Proteins. *ANNALS OF SURGERY*, **112**, 502, 1940.

## SHOCK TREATMENT

- <sup>32</sup> Elser, W. J., Thomas, R. A., and Steffen, G. I.: The Desiccation of Sera and Other Biological Products (Including Microorganisms) in the Frozen State with the Preservation of the Original Qualities of Products So Treated. *Jour. Immunol.*, **28**, 433, 1935.
- <sup>33</sup> Flosdorf, E. W., and Mudd, S.: Procedure and Apparatus for Preservation in "Lyophile" Form of Serum and Other Biological Substances. *Jour. Immunol.*, **29**, 389, 1935.
- <sup>34</sup> Shackell, L. F.: An Improved Method of Desiccation, with Some Applications to Biological Problems. *Amer. Jour. Phys.*, **24**, 325, 1909.
- <sup>35</sup> Greaves, R. I. N., and Adair, M. E.: High-Vacuum Condensation Drying of Proteins from the Frozen State. *Jour. Hygiene*, **39**, 413, 1939.
- <sup>36</sup> Flosdorf, E. W., and Mudd, S.: An Improved Procedure and Apparatus for Preservation of Sera, Microorganisms and Other Substances. The Cryochem-Process. *Jour. Immunol.*, **34**, 469, 1938.
- <sup>37</sup> Hill, J. M., and Pfeiffer, D. C.: A New and Economical Desiccating Process Particularly Suitable for the Preparation of Concentrated Plasma or Serum for Intravenous Use: The Adtevac Process. *Ann. Int. Med.*, **14**, 201, 1940.
- <sup>38</sup> Flosdorf, E. W., Stokes, F. J., and Mudd, S.: The Desivac Process for Drying from the Frozen State. *J.A.M.A.*, **115**, 1095, 1940.
- <sup>39</sup> Stokes, F. J.: Personal communication, 1940.
- <sup>40</sup> Edwards, F. R., Kay, J., and Davie, T. B.: The Preparation and Use of Dried Plasma for Transfusion. *Brit. Med. Jour.*, **1**, 377, 1940.
- <sup>41</sup> Harper, S. B., Essex, H. E., and Osterberg, A. E.: The Preparation and Experimental Use of Dried Blood Plasma. *Proc. Staff Meet. Mayo Clinic*, **15**, 689, October 30, 1940.
- <sup>42</sup> Thalheimer, W.: A Simple, Inexpensive Method for Concentrating Serum under Sterile Conditions. *Proc. Soc. Exp. Biol. and Med.*, **37**, 630, 1938.
- <sup>43</sup> Mellanby, J.: Diphtheria Antitoxin. *Proc. Roy. Soc. (London)*, B, **80**, 399, 1908.
- <sup>44</sup> Ferry, R. M., Cohn, E. J., and Newman, E. S.: Studies in the Physical Chemistry of the Proteins. XIII. The Solvent Action of Sodium Chloride on Egg Albumin in 25 per cent Ethanol at -5°. *Jour Am. Chem. Soc.*, **58**, 2370, 1936.
- <sup>45</sup> Cohn, E. J., Luetscher, J. A., Oncley, J. L., Armstrong, S. H., and Davis, B. D.: Preparation and Properties of Serum and Plasma Proteins. III. Size and Charge of Fractions Separating upon Equilibration Across Membranes with Ethanol-Water Mixtures of Controlled pH, Ionic Strength and Temperature. *Jour. Am. Chem. Soc.* In Press.
- <sup>46</sup> Schmidt, C. L. A.: The Chemistry of the Amino Acids and Proteins. Baltimore, Charles C. Thomas, 1938, p. 280, *et seq.*
- <sup>47</sup> Lower and King: *Phil. Trans.*, **2**, 557, 1667.

DISCUSSION.—DR. ROY D. MCCLURE (Detroit, Mich.): I am very glad, at Doctor Blalock's request, to tell you of the method of desiccating blood plasma, now successfully in use at the Henry Ford Hospital. Dr. Frank W. Hartman, Director of our laboratory, did not at first start to make dried plasma. He was trying to eliminate reactions following intravenous therapy due to impure rubber, or dirty tubing.\* He conceived the idea of using cellophane tubing instead of rubber. He first used tubing made for dialysis but later obtained the tubing prepared for sausage casings, and it has proved satisfactory in our now extensive experience. This tubing has the advantage of compactness. In a small bottle, it is sterilized under steam pressure, and is thrown away when we have used it once.

Doctor Hartman then tried cellophane bottles. Fluid, however, was lost rather rapidly through their walls. This loss was through osmosis and not

\* Hartman, F. W.: The Elimination of Rubber Tubing on Intravenous Sets, *ANNALS OF SURGERY*, **111**, 498-501, March, 1940.

due to filtration. It then occurred to him that desiccated blood plasma could be prepared by using this principle. (Slide) (This diagrammatic representation is published in the current issue of the J.A.M.A., Dec. 7, 1940, Vol. 115, pp. 1989-1990, by Doctor Hartman.) He now makes large double walled cellophane cylindrical tubing 16 and 24 inches in length. Between these two walls of cellophane the blood plasma is poured with a quantity of filtered air. A number of these cylinders are supported between the rims of two wheels, mounted on the same axle, at a suitable distance. A large fan at one side circulates the air through the center and around the outside of each cylinder as the wheels are turned by a small motor (rotor-pervaporator). This rotation produces foaming and the end-product is a light airy material which may be readily broken up (Fig. 1). Plasma desiccated in this manner is readily regenerated when we wish to use it. In emergency, we may regenerate it in the same cellophane containers either by immersing the cylinder in distilled water or by opening the same and adding distilled water.

We have used this powder in our operating rooms now for some months, and it has proved very satisfactory. We know that this method is a satisfactory one for drying plasma. It has an advantage in the rapidity of desiccation, solubility of the product, and low cost.



FIG. 1.—Cellophane cylinder containing foamy, desiccated plasma.

DR. WALTMAN WALTERS (Rochester, Minn.): Two years ago, while on a visit to European clinics, it was interesting to find that in the Serum Institute, in Copenhagen, the Director had instituted a method by which the blood-group of each soldier was recorded on his name plate. In view of the fact that blood is being drawn from recruits for complement fixation tests, it would be an easy matter to have the blood grouped and the result placed on the proper identification plates. The advantage of that would be apparent in the field, where blood transfusion could be carried out immediately. It should be possible to train large numbers of persons, both in the medical corps and in the line, to draw blood and reinject it, provided suitable containers were always available. Transfusions of blood serum and plasma have been of great value. Why not draw 200 to 500 cc. of blood from each recruit, dry the plasma and store it for use when necessary? It would seem that the method of drying blood plasma for transportation and storage will probably be of great advantage in war casualties.

In recent issues of "The Military Surgeon"\*\* there were several excellent articles,<sup>1, 2, 3</sup> translated from the German, about the transportation of the

\*<sup>1</sup> Hippel, Major General Erich: Transport by Air of the Sick and Wounded. Mil. Surg., 86, 439-444, May, 1940.

<sup>2</sup> Tönnis, W.: Air Transportation of the Sick and Wounded a Medical Problem. Mil. Surg., 87, 22-25, July, 1940.

<sup>3</sup> Schmidt, Staff Surg. Frederick: Transportation of the Wounded by Plane. Mil. Surg., 87, 136-141, August, 1940.

## SHOCK TREATMENT

wounded by air. One cannot but be impressed by the effect of the difference in the concentration of oxygen and nitrogen on patients with chest and abdominal injuries who are being flown at high altitudes. It should not be difficult, with the pressure chambers now being built, for cheap chambers to be obtained to study these problems on animals. It seems to me, too, that it would be well worth while to send men to the various institutions in Canada where research is being carried out in connection with war medical problems for suggestions relative to investigative problems in war medicine.

I should like, again, to call attention to a worth while suggestion—the routine grouping of blood on all recruits, with the group placed on their identification name plates.

DR. BRADLEY L. COLEY (New York, N. Y.): I thought you might be interested in actual accounts of British opinion regarding the use of plasma and serum for war victims. At the request of Dr. C. P. Rhoads, of the Plasma Division of the Blood Transfusion Betterment Association, I put some questions to Professor G. Grey-Turner, of the British Post-Graduate Medical School, and to Dr. Philip D. Wilson, Director of the American Hospital in Britain, and through these men I received replies from Sir E. Mellanby, of the Medical Research Council, and Janet Vaughan, Medical Officer in Charge of the Ministry of Health and Medical Research Council. The former made the following statement:

"The British reserves of donors have not been exhausted; in point of fact they have been scarcely tapped. The national transfusion scheme is not yet under way, and it is doubtful if it will be in full swing before the New Year. The four depots near London, administered by the Medical Research Council, are the only units bleeding steadily, and they anticipate there will be no difficulty in keeping up their present rate of bleeding for some months.

"The preference is for dried serum. The reasons for this are:

- (1) That serum can be bacteriologically filtered through Seitz pads.
- (2) That the dried product keeps indefinitely.
- (3) That if a chance organism gets in during the process, there is no opportunity for this to grow and produce toxins.

(4) It can be produced without the addition of an antiseptic.

(5) There is no evidence that it is a 'toxic fluid.'

"On the other hand, citrate plasma has the following disadvantages:

- (1) It clots after filtration through Seitz pads.
- (2) If it is issued without being filtered, it is opalescent and subsequent infection cannot be detected.

(3) That there is a suspicion that after some time the antiseptic action of merthiolate dies out, and that organisms, if present, begin to grow.

(4) That reports are coming in of brisk reactions after plasma, due presumably to using infected plasma.

"During the air raids on London during September, it may be assumed that approximately 1,500 casualties were transfused, the majority with plasma. The amount given to each patient varied from 1,000 to 2,500 cc."

I was surprised at the large amount of plasma required for each patient, but this was substantiated by a letter from Janet Vaughan, as follows:

"Recent figures from the Middlesex Hospital are: 130 air raid casualties; 22 needed transfusion; average dose four and one-half bottles of plasma.

"(1) We really need plasma sent from the U.S.A. It is not merely a question of apparatus.

"(2) Our supplies of donors are not exhausted, they are constantly

growing, but in view of the large quantities needed by each casualty, four and seven pints as a minimum, very large amounts of plasma are needed.

"(3) We prefer dried serum to liquid plasma for some purposes—

(a) Ease of transport, and lack of necessity for refrigeration.

(b) It is much easier to make sterile dried serum than it is to make sterile liquid plasma. Dried plasma is not used because preparation is unsatisfactory.

"(4) I cannot give precise figures as to the numbers of transfusions of plasma given in the last few months in the whole country, but all the available plasma has been used. I have issued for use in the N.W. London area 1,238 bottles since August 1st. All reports on the use of plasma are most enthusiastic."

DR. ALFRED BLALOCK (Nashville, Tenn., closing): Doctors Hartman and McClure are to be complimented on their excellent work. This modification of the cellophane method is a real advance; and if this powder can be restored to the liquid form readily, and if it is sterile and not denatured, it will probably be used very extensively.

Aside from the military aspects, it is obvious that the ready availability of whole blood in banks, and of liquid or dried plasma, will result in the more frequent use of these solutions. It should be generally recognized that these solutions should be used for the prevention of the decline in blood pressure as well as for treating shock that has already developed. Blood or blood substitutes should be available for immediate administration in all major operative procedures in which the need for supplementing the blood volume might arise.

The custom of administering one pint of blood in the prevention or treatment of shock is too prevalent. It apparently arose from the fact that a donor may give one pint of blood with no danger and little inconvenience. It is important that blood should be given in adequate amounts according to the needs of the patient. If one pint does not suffice, that does not mean that several pints might not save the patient.

## PERIPHERAL VASCULAR INJURIES\*

I. A. BIGGER, M.D.

RICHMOND, VA.

PERIPHERAL VASCULAR INJURIES frequently involve both artery and vein but the arterial injury is more important, for, due to the high arterial pressure, hemorrhage is more profuse and more difficult to control. Furthermore, obstruction to the flow of blood through a main artery is more apt to produce serious damage to the tissues than is obstruction of the return flow in the concomitant vein. When a large vessel of the trunk, either artery or vein, is injured, fatal hemorrhage frequently occurs because the vascular wound usually communicates directly with one of the body cavities. Perforation of a large peripheral vein usually communicates with the surface by a narrow channel and, therefore, results in only moderate blood loss, for shifting of the muscle planes obliterates this channel and traps the blood in the tissues. This produces a rapid rise in the extravascular pressure and prevents further bleeding. Bleeding from a peripheral artery may be controlled in the same way, but a higher extravascular pressure is necessary to control arterial bleeding and this may produce serious obstruction to blood flow distal to the injury. As the extravascular pressure rises it first obstructs the veins, then the arteries, including the collateral channels. The absence of pulsation in the small vessels and the increased pressure at the level of injury result in lymph stasis and edema. The edema causes further interference with the circulation, so the net result is the establishment of a vicious circle which leads to gangrene unless the pressure on the collateral channels is promptly relieved.

This sequence of events illustrates one way in which serious difficulty may arise as the result of injury to a major peripheral artery. There are many other possibilities, such as ischemic gangrene from obstruction of important vessels which have insufficient collaterals—for example, the popliteal arteries—the development of false aneurysms, etc.

It is essential, therefore, that surgeons be aware of the physiologic and pathologic sequelae common to vascular injuries as well as the specific sequelae likely to result from wounds of certain vessels. It is also necessary that they be familiar with the symptoms and signs associated with such sequelae.

Fortunately, the evidence necessary for the diagnosis of wounds of the larger arteries may be obtained by careful physical examination, without the use of complex apparatus. The area adjacent to the wound should be examined for evidence of massive infiltration of the tissues with blood and for pulsation outside of the line of the artery. The vessels distal to the injury should be palpated and the volume of the pulse compared with that of the

\* Presented before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 1940.

pulse in the corresponding vessels on the opposite and uninjured side. The superficial veins should be inspected and the levels at which these veins are full and collapsed should be compared with similar levels in the sound extremity. Also, the surface temperature and color in the two extremities should be compared. Finally, the area over the main vessels near the wound should be auscultated. Although the signs of vascular injury usually are not difficult to demonstrate, they may be obscured in the presence of profound shock. Furthermore, there are often progressive changes in the physical signs, so examination as outlined above should be repeated if the original evidence is inconclusive.

The treatment of vascular injuries depends upon many factors such as the vessel injured, the presence of persistent or recurrent hemorrhage, the condition of the distal circulation, the general condition of the patient, and the available facilities. Immediate steps to control hemorrhage should be taken if there is active bleeding when the patient reaches a First Aid Station. This would seem obvious. However, the desirability of avoiding further trauma in the presence of shock has been so emphasized, that it now seems advisable to stress the necessity for the immediate control of active hemorrhage even in the presence of severe shock. Bleeding from large vessels may be controlled by the application of ligatures, by digital pressure, or by a tourniquet. If the vessel is exposed by extensive destruction of the overlying tissues, it should be doubly ligated and divided between the ligatures. When a narrow tract connects the wound in an artery with the surface, strong digital pressure over the artery at the site of injury may permit the formation of a clot which will control bleeding until the patient can be transferred to a station with adequate facilities for surgery. If the wound involves an extremity, a tourniquet should be applied proximal to the wound during such transfer; but the tourniquet should not be tightened unless hemorrhage recurs. The tourniquet should be used only when hemorrhage cannot be controlled by other means. If there is no alternative, a patient may be transferred from one station to another with a tourniquet in use. However, the transfer must be made as rapidly as possible and a sign should be attached to the patient's clothing calling attention to the presence of a tourniquet, so that it will be removed and hemorrhage controlled by other means at the earliest possible moment. If a tourniquet is employed too long, gangrene is inevitable.

When a patient with injury to a major vessel reaches a station with adequate facilities for surgical intervention, the decision must be made as to whether or not immediate operation is indicated. Early operation is indicated if there is continued or recurrent bleeding, inadequate circulation distal to the wound, or if there is a large amount of devitalized tissue. If there is massive local swelling and poor circulation beyond, exploration should be undertaken, and as much clot evacuated as possible. The wounded artery should be inspected to determine whether it is amenable to repair or requires ligation. Even though the artery has to be ligated, the circulation will usually be improved by the relief of pressure on the collateral channels. However,

## PERIPHERAL VASCULAR INJURIES

if there is no bleeding and no reason to suspect that organic material, such as shreds of clothing, has been carried in with the missile, and if the circulation distal to the point of injury is satisfactory, it may be advisable to delay operation. Superficial infection is an indication for delay because the entire operative field is apt to become infected if operation is performed under such circumstances, whereas if proper conservative measures are employed this is unlikely. Diffuse pulsation in the region around the wound is not necessarily an indication for early operation, for pulsating hematomata may heal spontaneously. They may become localized and converted into false arterial aneurysms or arteriovenous aneurysms, depending upon whether the wound involves the artery alone or the artery and vein. Direct arteriovenous connections, without associated pulsating hematomata, may heal or may persist as arteriovenous fistulae (aneurysmal varices). When any of these conditions are present, and the distal circulation is adequate, operation should be delayed for two or three months, unless some indication for immediate interference, such as secondary hemorrhage, arises. Such delay permits improvement of the collateral circulation and gives time for the disappearance of pathogenic organisms from the adjacent tissues.

Whether or not immediate operation is decided upon, shock should be controlled, and when possible the blood volume and cell content should be restored.

If secondary hemorrhage occurs, it is necessary to expose the wound in the artery and repair it or ligate the vessel. If suture is not feasible, heavy silk ligatures should be applied both proximal and distal to the vascular wound, and the vessel divided between them. Proximal ligation of the artery at a distance from the wound is usually contraindicated when the artery alone is injured, and should never be undertaken when there is a communicating wound between the artery and vein.

Vascular suture, with maintenance of the lumen of the main artery, is the ideal procedure, but in World War I this was not often feasible. Such may also be the case in the present war for, as pointed out by Bernheim,<sup>1</sup> and others, the press of patients is so great and contaminations are of such common occurrence during active fighting, that the more refined surgical procedures have to be replaced by others more crude but life-saving to a greater number. The following objections have been advanced against suture: (1) It is more time-consuming and, because of the necessity for prolonged anesthesia, is probably more shocking than ligation; (2) it requires more refined instruments and suture material, which are not always available; (3) if gross infection occurs, the danger of secondary hemorrhage is increased; and (4) in many instances the vascular damage is so extensive that direct suture is not practical, and venous transplants have not often been successful. However, with the present methods of warfare there will probably be an increased incidence of vascular wounds made by small fragments of metal—such small wounds being most suitable for repair. Furthermore, the production of clinically effective heparin has increased the chances of success in end-to-end

suture. Murray and Best<sup>2</sup> have shown that with regional heparinization, 80 per cent of vessels remained patent following end-to-end suture, and 70 per cent remained patent when venous transplants were used. While regional heparinization seems to have a number of advantages over the systemic use of this substance, the latter should be employed when, for any reason, regional administration is not feasible. Since thrombosis at the suture line may usually be prevented by the use of heparin, and the incidence of infection reduced by chemotherapy, it would seem wise to suture wounds of such arteries as the carotid, popliteal, and common femoral, because there is danger of ischemic gangrene when these arteries are suddenly occluded. Success in this type of vascular surgery requires a high degree of technical skill even with the aid of heparin. Since the incidence of vascular injuries is small in civilian practice, surgeons should perfect their technic in vascular suture in the experimental laboratory.

The danger of severe infection and secondary hemorrhage is reduced by the systemic and local use of the sulfonamide derivatives. We believe that this is particularly true of the local application of sulfanilamide which we have now employed for three years in all obviously contaminated wounds. Unfortunately, I have not had the opportunity to make a careful study of our records in these cases, but I am convinced that the incidence of infection is reduced to a greater degree than can be explained on the basis of systemic absorption of the drug. The only objection to the local use of sulfanilamide powder, of which I am aware, is that it increases bleeding. In our experience this has not been important. We, therefore, advocate the local application of sulfanilamide in contaminated wounds, urging, also, that other measures, such as débridement, be carried out with meticulous care.

When suture of an artery is not feasible, ligatures must be applied and the vessel divided between them. Catgut is usually recommended for ligatures when there is active infection, but I agree with Reid<sup>3</sup> that silk is especially indicated under such circumstances, and that large ligatures should be used for large arteries, as the larger ligatures are less likely to cut through.

Ischemic gangrene is particularly apt to follow sudden obstruction of the popliteal, common femoral, carotid, and axillary arteries. It is, therefore, essential when one of these arteries is obstructed that every precaution be taken to prevent circulatory insufficiency. The following measures, discussed in the order of their importance, should be considered in this connection, as any or all of them may be applicable in a given case:

(1) *Sympathetic Nerve Block.*—Blocking of the sympathetic nerves to the involved area, as suggested by Gage and Ochsner,<sup>4</sup> and their associates, is probably the most important measure yet recommended for the improvement of the collateral circulation after the sudden occlusion of an important artery. It relaxes the spasm of the branches of the obstructed vessel and thereby increases the blood flow through the ischemic area. It may be accomplished (a) by the injection of novocain; (b) by the injection of alcohol; or (c) by operation, which is usually unnecessary. The injection of novocain, repeated

as often as is necessary, is usually the method of choice in patients with acute obstruction of otherwise normal vessels. In elective ligation the sympathetic nerves should be blocked both before and after operation, and in accidental occlusion of an artery they should be blocked as soon afterward as possible.

(2) *Prevention and Control of Infection.*—The extent of the associated injury and the occurrence of infection are important in determining the incidence of gangrene following vascular occlusion. In large wounds infection becomes more serious but the extent of the original injury, of course, cannot be controlled. It is essential that all available measures be employed to prevent infection by the usual pyogenic organisms and especially by the gas-forming anaerobes. The measures especially indicated are careful cleansing with warm normal saline solution, careful débridement, avoidance of tension if closure is attempted, and leaving the wound open if there is infection, local and systemic use of the sulfonamide derivatives, and administration of gas bacillus antitoxin. Blood replacement also helps to prevent infection.

(3) *Occlusion of the Concomitant Vein.*—Makins<sup>5</sup> established the value of this procedure in clinical cases, and Brooks and Martin,<sup>6</sup> Holman and Edwards,<sup>7</sup> and others, have demonstrated its effectiveness in experimental animals. The reasons for this are not clear, for Brooks and Martin have shown that obstruction of the concomitant vein, after obstruction of the artery, further decreases the volume flow of blood through the tissues distal to the occlusion, but they suggested that there was probably a better distribution of the blood going through. Holman and Edwards demonstrated that there was a higher intravascular pressure distally, and a greater increase in the minute volume-flow of blood from the distal end of a divided artery when the accompanying vein was ligated proximal to the arterial occlusion, than when the vein was obstructed at the same level as the artery. They, therefore, advocated ligation of the iliac vein when it was necessary to tie the femoral or popliteal artery. While the rationale of concomitant vein ligation is not clear, there seems to be little doubt of its effectiveness in reducing the incidence of ischemic gangrene, and since it apparently produces no important undesirable after-effects, it is indicated when such arteries as the femoral and popliteal are occluded.

(4) *Position of Involved Extremity.*—Rest and elevation of the affected extremity are so commonly observed in the treatment of thrombophlebitis that many physicians have adopted these measures in the treatment of all vascular disorders. Rest is a necessary measure following arterial occlusion, as muscular exertion increases the oxygen demand, but constant elevation of the part is obviously contraindicated in most instances of arterial occlusion. As suggested by Reid,<sup>8</sup> the extremity should be placed at a level at which the veins are normally full. Alternate elevation and depression of the extremity may be indicated when there is edema.

(5) *Avoidance of Undue Pressure.*—Tight circular dressings must be avoided, as they interfere with the flow through the collateral vessels, and

especial care should be exercised to avoid prolonged local pressure—as, for example, over the heel or external malleolus.

(6) *Local Temperature Control*.—An attempt should be made to maintain the temperature of the part at the normal level. This is probably best accomplished by the application of voluminous dressings of some warm, soft material such as cotton wool. External heat should be applied with care, and moist heat must be avoided.

(7) *Pavaex Machine*.—Generally speaking, the Pavaex machine is contraindicated when there is an extensive wound, and must not be employed in the presence of active infection. It is of no value when arteries are obstructed so near the trunk that the cuff cannot be applied proximal to the obstruction. When the arterial lesion is sufficiently distal, the Pavaex machine may be used, provided there are no contraindications such as wound infection.

(8) *Other Measures*.—As previously stated, the blood volume and cell content should be restored when possible, for this not only aids in the prevention and control of infection but also increases the amount of oxygen reaching the tissues. In other words, local anemia is accentuated by general anemia, and to some extent is relieved by blood replacement. In this connection, if there is cyanosis due to associated thoracic injury or pulmonary infection, an attempt should be made to relieve it by the administration of a high concentration of oxygen.

Satisfactory vasodilator drugs are not available. Nicotinic acid apparently has some value. Papaverin is rather widely used but its effect is uncertain.

#### CONCLUSIONS

The treatment of injuries to the major peripheral vessels forms an important part of modern war surgery. In the past, even during the World War I, vascular suture was not often feasible, and ligation, either immediate or delayed, was the usual method of treatment. Since we now have more effective means of preventing thrombosis at the line of suture, and of combating infection, suture should play a more important rôle in the treatment of vascular injuries. The incidence of peripheral gangrene should, thereby, be materially reduced.

When important arteries are occluded certain measures should be employed to combat ischemia, among them ligation of the concomitant vein or veins and sympathetic nerve block. The latter is especially valuable and should be undertaken immediately if there is any evidence of insufficient collateral circulation. In addition to these local measures, certain general measures must also be given consideration. The most important of these is blood replacement.

#### REFERENCES

- <sup>1</sup> Bernheim, Bertram M.: Surg., Gynec., and Obstet., **30**, 564, 1920.
- <sup>2</sup> Murray, Gordon D. W., and Best, Charles H.: ANNALS OF SURGERY, **108**, 163, 1938.
- <sup>3</sup> Reid, Mont R.: Surg., Gynec., and Obstet., **58**, 287, 1934.
- <sup>4</sup> Gage, Mims, and Ochsner, Alton: Arch. Surg., **112**, 938, 1940.

## PERIPHERAL VASCULAR INJURIES

<sup>5</sup> Makins, George H.: Gunshot Injuries to the Blood Vessels. John Wright and Sons, Ltd. Bristol, 1919.

<sup>6</sup> Brooks, Barney, and Martin, K. A.: J.A.M.A., **80**, 1678, 1923.

<sup>7</sup> Holman, Emile, and Edwards, Muriel E.: J.A.M.A., **88**, 909, 1927.

<sup>8</sup> Reid, Mont R.: Am. Jour. Surg., **24**, 11, 1934.

DISCUSSION.—DR. JOHN W. PRICE (Louisville, Ky.): There are one or two points I want to speak about. The first one is that I cannot share his enthusiasm for the operation of suturing blood vessels. I had been suturing blood vessels in the laboratory for eight years; and during my entire service in the war, in Evacuation Hospitals Nos. 1, 7, and 15, I did not have an opportunity to suture one vessel. I did have an opportunity to tie every large peripheral vessel, and I had no trouble in doing so.

I think many a boy lost an arm or a leg in the last war because a tourniquet was applied in the field by an enlisted man. In many cases the hemorrhage could have been controlled by a pack of gauze and a light bandage instead of a tourniquet. In the coming war I hope that more attention will be given to this point.

DR. DERYL HART (Durham, N. C.): In my opinion proximal ligation should be used only where it is impossible, or inadvisable, as in an infected wound, to expose the damaged point in the vessel, and where proximal ligation may be a life-saving procedure. I am sure Doctor Bigger agrees with this, and I simply wish to emphasize this point. My only experience with proximal ligation has been in the capacity of a consultant whose advice, to explore and suture the perforation of the femoral artery or to ligate the artery just proximal and distal to the injury, was ignored. The surgeon felt that it was simpler to undertake a proximal ligation in Scarpa's triangle, instead of exploring the vessel in Hunter's canal, with the tissues extensively infiltrated with blood. This operation was followed by a rapidly developing gangrene, which was made more likely by the following conditions:

(1) The continuity of the patent artery was interrupted at two well-separated points, thus requiring a much wider bridge of collateral circulation to carry blood from the artery proximal to the ligation to the extremity distal to the point of injury.

(2) The leak in the artery was not closed (except possibly by the blood clot, extravasation of blood, and tension beneath the fascia) so continued leakage of blood may have made it impossible for the collateral circulation to maintain sufficient pressure in the peripheral arterial system to keep the tissues alive.

(3) The blood clot was not evacuated and the tension beneath the deep fascia was not relieved, so that the resultant compression of the collateral vessels interfered seriously with the development of an adequate collateral circulation.

(4) With an initial adequate collateral circulation the continual extravasation of blood from the injured artery might still further increase the tension beneath the fascia and render these collateral routes inadequate.

In view of these factors it seems imperative that if ligation is necessary it should be performed, if at all feasible, immediately proximal and distal to the point of injury, without any intervening tributary vessels.

DR. ALTON OCHSNER (New Orleans, La.): I want to emphasize the importance of the abolition of the vasoconstrictor impulses in lesions of the peripheral arteries, which Doctor Bigger has referred to. Doctor Gage, of

our Clinic, has done a great deal of work on this, and has shown that if this is undertaken as a preliminary measure, ischemic gangrene in the extremities need not be feared in operations upon the peripheral vessels. Several years ago, Doctor Gage reported, before this Association, a case in which a mycotic aneurysm of the common iliac artery was successfully ligated without any disturbance of the vascularity of the extremity. This was made possible by a preliminary blocking with alcohol of the lumbar sympathetic ganglia on the side. In patients with injuries of the peripheral arteries, vasospasm is an important factor in producing ischemia. This can be satisfactorily treated by abolishing the vasoconstrictor impulses by novocain block of the sympathetic ganglia. The greater the degree of trauma the more urgent the need for the sympathetic block. Even in peripheral arterial embolism, the removal of the associated vasospasm in the collaterals will overcome the ischemia, and embolectomy is seldom if ever necessary.

As a result of Doctor DeBakey's and my investigations in thrombophlebitis, we are convinced that the vasospastic influences originating in an injured or inflamed portion of the vascular system produce spasm of the associated collaterals, particularly the arterioles, resulting in interference with the blood supply. This may be so severe that ischemic gangrene can result. All of these manifestations can be prevented and satisfactorily treated by either repeated novocain block of the lumbar sympathetic ganglia or an alcoholic block which produces a more lasting dilation.

DR. JOHN C. A. GERSTER (New York City): I would like to call attention to the possibility of secondary hemorrhage after ligation of main vessels in the presence of infection—no matter how mild—as most likely to occur from the seventh to the tenth day after ligation.

In Billroth's Clinic, in preantiseptic days, this fact was so well known that tourniquets were provisionally placed during these critical days so they might be instantly tightened in the event of secondary hemorrhage.

DR. I. A. BIGGER (Richmond, Va., closing): Doctor Hart apparently misunderstood my statements with regard to proximal ligation. I stated that proximal ligation, at a distance, should rarely be performed when the artery alone is injured, and never when there is a communicating wound between the artery and vein. I can conceive of circumstances under which proximal ligation may be advisable, but it certainly is not to be undertaken unless there is an excellent reason for doing so.

Vascular suture was not often feasible in the last war, and this may be true during the present war, but the opportunity for suture should be greater now.

The time to employ sympathetic block is prior to occlusion in elective cases, and at the earliest possible moment after accidental occlusion.

## UROGENITAL INJURIES\*

PARKE G. SMITH, M.D.

CINCINNATI, OHIO

A DISCUSSION of the urogenital injuries occurring in the present war is necessarily a brief and a theoretic one, for as yet there have been absolutely no reports of this subject in any of the very few foreign periodicals that are being received in this country to-day, but I believe the knowledge that we do have of the type of this conflict will allow us to rather accurately visualize the probable nature and frequency of the genito-urinary war injuries at this time. Whether such an analysis will be of value when and if we take an active part is questionable, for the method of combat and the methods of producing casualties are changing very rapidly.

As a result of the experience of urologists during the last war, some very definite statistical information dealing with the frequency and type of urologic injuries in war was obtained. It appears that approximately 7 per cent of all penetrating abdominal wounds were accompanied by renal damage, and that in 4 per cent the bladder was ruptured. Ureteral injuries were of great rarity. Doctor Young states that wounds of the external genitalia were far more frequent than those of any other portion of the genito-urinary tract, there being 164 cases in the Service records of the A.E.F. Due to the necessary delay in diagnosis and treatment of the injured, as well as the almost universal presence of accompanying damage to other parts of the anatomy, we would expect these cases would show a very high mortality, but it is surprising that as many as 61 per cent of the bladder cases died, and 25 per cent of the kidney cases were fatal. Even in those cases where the injury was confined to the external genitalia 2.3 per cent died. This is, apparently, a rather high mortality, and one that should be given serious thought.

Injuries of these organs are of such a serious nature that the individuals so affected, be they civilian or members of the armed forces, immediately become factors that interfere with the efficiency of the military action, whether that be offensive or defensive.

Military efficiency demands their prompt evacuation to a nonmilitary area. Humanitarian principles demand their prompt arrival in such areas, for it is only in such areas that the special services necessary for complete diagnosis and correct therapy can be maintained upon a basis of permanency sufficient to assure efficiency.

Due consideration to these facts should materially lower the mortality statistics previously mentioned. This problem of prompt evacuation of major casualties is undoubtedly being intensely studied by the Surgeon-General's office.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

The accuracy of the previously mentioned incidence rates, which have been compiled by well known authorities cannot be questioned, but I doubt if they are of any particular value to those who are charged with the responsibility of the urologic injuries occurring in the present conflict, for this war is different, as different from the last as the last was from the Crusades.

It is to be remembered that during the last war combat was of a rather personal nature—more or less man-to-man—and that, broadly speaking, casualties were the result of penetrating wounds such as those produced by bullets and shell fragments. Casualties were confined almost entirely to those of the armed forces. But now, combat, if you can call it such, is a rather one-sided affair, ultramechanized units of one nation preying upon the civilian population of the other. On only rare occasions do the men of the armed forces actually fight each other. I should imagine that to-day the civilian casualty list is far greater than that of the armed forces.

Casualties are now produced in an entirely different way than they were 25 years ago, for now, during this period of ultramechanization, the damaging factor is massive, crushing force rather than the penetration by bullets or shell fragments. Consequently I feel that we are warranted in believing that the injured who do not immediately die are usually very seriously hurt. Hence, we should expect a marked increase in the severity and probably in the frequency of such things as ruptured kidneys and bladders. Casualties in the military service, itself, are probably more extensive and serious than in any other war, for if you can get a ruptured kidney or bladder as the result of an automobile "turn over," visualize just what would happen to you if you were in a tank or airplane?

In other words, I believe that the type of genito-urinary injuries occurring in to-day's conflict are quite comparable to those which we are seeing in our civilian practice with greater frequency each year, as the result of the constantly increasing number of automobile accidents. From the experiences gained in the Urologic Services connected with our larger general hospitals, where a great deal of traumatic urology is seen, certain lessons have been learned and certain basic principles established which, I think, may be easily applied to the conditions that are being seen in Europe to-day, and to which we, as doctors, may be required to give our personal attention in the not far distant future.

The most logical classification of renal damage is that of Stirling, who recognizes four groups: (1) In which there is minimal damage, with minor hemorrhage, a slight tearing of the renal capsule, and little or no damage to the renal parenchyma; (2) one or all of these are more severe; both of these types respond to conservative therapy. (3) There is actual major damage to the renal parenchyma, fracture of the capsule and massive hemorrhage both extracapsular and intrarenal. It is in this type that our therapeutic principles have materially changed during the past few years, for formerly we were inclined to treat these cases very conservatively, and many times were apparently successful.

## UROGENITAL INJURIES

A study of those cases that were supposedly handled successfully by conservative measures, and the results of Stirling, in his animal experimentation, have shown that the functional integrity of a third degree damaged kidney is frequently jeopardized, if not actually destroyed, by conservatism. It is now generally agreed that such a kidney should be exposed by a flank incision, the clot evacuated, hemorrhage controlled, and any definitely indicated reparative surgery carried out. (4) Damage is so extensive that the life of the individual can be best assured by prompt nephrectomy.

In ureteral injuries, immediate recognition of the nature of the injury is demanded in order that pyelotomy may be performed, and thus save a kidney until such time as plastic ureteral surgery can be safely undertaken.

Air-raid casualties among the civilian population will, I am certain, show a marked increase in the incidence of bladder rupture, particularly of the intraperitoneal type. Rupture of the bladder, whether it be of the extra- or intraperitoneal type, requires prompt recognition and immediate cystotomy. This is likewise true in cases of urethral rupture.

Efficient therapy of injuries of the urinary tract demands full recognition of the necessity of maintaining an unobstructed flow of urine from all parts of the tract, even if surgery is necessary to establish such drainage. Hemorrhage, of course, must be controlled, and its effects overcome by prompt utilization of to-day's accepted procedures.

Organs of the genital tract of the male may be treated conservatively, if infection is controlled, for the reparative ability of that part of the anatomy is well known.

As in all traumatic surgery the control of infection is a matter of major importance in the therapy of urogenital injuries. The remarkable advance of chemotherapy, during the past two or three years, has greatly increased our ability to deal with this problem of infection. The use of sulfanilamide as an irrigating solution, dilute as it necessarily is, of sulfanilamide and sulfathiazole as powder dressings, and of sulfapyridine and sulfathiazole internally, have been most effective.

In this connection, I should like to call to your attention that it is the belief of Doctor Alleya that, apparently, the maximum effect of sulfathiazole and sulfapyridine in urinary infections is obtained by comparatively small doses, namely, 2 Gm. per day for an individual weighing 150 pounds.

In conclusion, may I say that, in my opinion, the urogenital injuries sustained during this war will be as frequent and possibly of a more serious nature than those of the last war; and I should like to repeat that the effectiveness of their therapy will be greatly increased by their prompt arrival at a place where they can have the benefit of those specialized diagnostic and therapeutic procedures that can be efficiently maintained only upon, at least, a semipermanent basis.

## INJURIES TO THE CHEST\*

DANIEL C. ELKIN, M.D., AND M. H. HARRIS, M.D.

ATLANTA, GA.

FROM THE DEPARTMENT OF SURGERY, EMORY UNIVERSITY, ATLANTA, GA.

THE DANGER from chest wounds is in a large measure due to the narrow margin of safety under which the thoracic viscera work. A rapid change of pressure relationships within the thorax affects the aeration of the blood, the filling and emptying of the heart, and the circulation not only in the thorax but also of the whole body. A knowledge of certain fundamentals of the mechanics of respiration is, therefore, a necessary prerequisite for the surgery of this field. Injuries affecting these relationships may be rapidly fatal and, therefore, worthy of immediate and heroic action.

With the respiratory passages open and the lungs at rest, the pressure within the lungs (the intrapulmonic pressure) is the same as that of the atmosphere; but with inspiration and expiration certain changes take place. With inspiration the pressure becomes slightly less than that of the atmosphere and with expiration the pressure rises slightly. These changes vary greatly with the intensity of the respiratory movements and with the size of the opening to the exterior. Forced expiration with the glottis closed raises the intrapulmonic pressure. A crushing pressure applied to the chest, as may happen in accidents, can raise it to such an extent that one or both lungs may be ruptured, even though the thorax is not penetrated.

The pressure within the thoracic cavity outside the lungs (the intrapleural pressure) is normally negative, due to the elastic recoil force of the lungs. It varies, too, with the depth of respiratory excursions. These changes affect not only the lungs but the whole cardiovascular system, since the intrapleural pressure, including that of the venae cavae as they enter the heart, is normally less than that of the atmosphere. If for any reason there is a change from a negative to a positive pressure, the filling and emptying of the heart is immediately affected.

Conditions are quite different with the thorax opened, and upon a recognition of these conditions are based the fundamental principles of most operative procedures within the thorax. If the opening in the chest is smaller than the larynx, the lung collapses, but on inspiration partial expansion occurs, and respiration in an individual with normal vital capacity is only slightly embarrassed. If the opening is larger than the laryngeal opening, air will enter more freely than through the trachea. The mediastinum will be forced toward the unopened side in inspiration and back toward the opened side in expiration. This condition, known as mediastinal flutter, probably subjects the heart and great vessels to varying degrees of positive and negative pressures.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## INJURIES TO THE CHEST

In addition, air passes from one lung to the other in useless exchange. All this may lead to rapid asphyxia. Therefore, the first principle in treatment of any sucking wound is immediate closure of the opening, preferably by suture of the skin, or by temporary plugging with the finger, the hand, or by the application of moist gauze.

The main consideration in the treatment of all chest injuries is: (1) The treatment of shock; (2) the arrest of hemorrhage; (3) the replacement of lost blood and fluids; and (4) the restoration of the physiology and dynamics of the cardiorespiratory system.

Thoracic injuries in civil life are different from those seen in war injuries, and are less severe. In the former, a knife, ice-pick, or pistol bullet are the usual weapons; and large sucking wounds, such as are made by shrapnel, are less frequently seen. The lodgment of clothes, ribs and shell fragments, giving rise to serious infection, is, therefore, more rarely a complicating factor.

Pleuropulmonary lesions may be divided into those having (1) open wounds of the thoracic wall; and (2) those having closed wounds. Open wounds are by far the more dangerous, the degree of danger depending upon the size of the wound, the amount of foreign material carried into the chest, and the injury to the viscera. Such wounds should be carefully cleansed, débrided, and sutured as soon as possible.

Pleuropulmonary lesions with a closed wound are more common and far less dangerous. They are usually caused by a knife or ice-pick, and the external wound has closed spontaneously or has been converted into a closed lesion by suture. The main problem in the treatment of thoracic injuries in civil life is, therefore, concerned largely with closed wounds and the conditions arising from injury to the thoracic viscera. Treatment is always dependent on the symptoms exhibited by the individual patient rather than by a set rule. In the main, the treatment is conservative and nonoperative, although operation is carried out for heart wounds, for large lacerated wounds of the lung, for hemorrhage from an intercostal or internal mammary vessel, or for compression pneumothorax.

Simple fracture of one or more ribs requires no special treatment other than immobilization and sedatives. Depressed fractures of ribs or sternum sometimes require elevation of the fragments either under general or local anesthesia. Multiple bilateral rib fractures are more serious because of the complicating factors of shock, hemorrhage and pneumothorax. The patient must be kept comfortable with opiates. Administration of oxygen, by means of the tent or the nasal catheter, often gives relief. Occasionally, in extensive multiple fractures, strapping of the chest makes the patient more uncomfortable, in which case the chest may be wrapped with heavy muslin or elastic stockinette. Nerve block may be tried for relief of pain.

Complications following fractures or any chest injury must be watched for and treated as they arise. The most common are: (a) Pneumothorax; (b) atelectasis; (c) emphysema; (d) hemothorax; (e) contusion and hemor-

rhage into the lung; (f) traumatic asphyxia; (g) paralytic ileus; and (h) empyema.

Traumatic asphyxia is due to violent but temporary compression of the chest. Two types are recognizable. The more common and more serious is characterized by short, uneven respirations. There is a general pallor of the face and neck with areas of purplish discoloration. The pulse is weak but fast, and the skin is cold and clammy. Often the patient is unconscious or stuporous. The treatment is that of shock and the administration of oxygen. If the patient recovers from shock, the prognosis is good. The more rare and less serious type is characterized by ecchymosis of the face, neck, and upper chest. It is caused by compression of the chest, with a sudden rise in the intrapleural pressure, which collapses the veins of the mediastinum, and forcibly ejects the blood into the valveless veins of the neck and head. There are subconjunctival hemorrhages, exophthalmos and hemorrhages into the skin. If uncomplicated, recovery takes place in seven to 20 days. Treatment is supportive with inhalation of oxygen.

Pleuritis is due to contusion of the pleura and may or may not be accompanied by one or more fractured ribs. The patient's chief complaint is pain on inspiration. There is usually a slight rise in temperature, and a friction rub may be heard over the injured area. Occasionally, the pleuritis is accompanied by a clear or bloody effusion. The treatment consists of strapping the chest wall and the administration of sufficient opiates to relieve the pain. Unless the fluid is excessive and respiration is embarrassed, it need not be removed by aspiration.

Injuries of the lung and pleura may produce two types of emphysema: (1) Subcutaneous; and (2) mediastinal. When the lung is torn, and a tension pneumothorax develops, air may be forced through an opening in the parietal pleura into the subcutaneous tissues of the chest wall or even over the greater part of the body. If the lung is injured internally, air may be forced along the peribronchial and perivascular tissues into the mediastinum and from there it may appear in the supraclavicular fossae or in the groin.

The majority of cases of subcutaneous (interstitial) emphysema require no treatment other than that for the chest injury. If the wound in the lung is valvular and the emphysema spreads rapidly, it may be necessary to explore the wound and close the opening in the pleura. Sometimes suturing the intercostal muscles together tightly will suffice, or inserting a needle or trocar into the chest and withdrawing the air. Rarely is it necessary to resort to multiple incisions to relieve the tension.

Emphysema of the mediastinum is rare. If the lung is injured internally, air may be forced along the peribronchial and perivascular tissues to the mediastinum. In cases where the trachea or large bronchi are injured there will probably be extensive mediastinal emphysema, which may greatly embarrass respiration and produce death unless the pressure is relieved. The symptoms are those of crepitus over the suprasternal notch, cardiopulmonary distress, and roentgenographic evidence of air in the mediastinum.

## INJURIES TO THE CHEST

The treatment of mediastinal emphysema depends on the amount of tension present. Some cases can be left alone entirely. Some can be successfully treated by aspirating the air from the pleural cavity, and relieving the tension in the mediastinum. Others have to be treated by incision over the suprasternal notch and allowing the air to escape through the opening. If the latter becomes necessary to prevent collapse of the intramediastinal vessels or trachea, then great care must be taken not to produce infection and mediastinitis.

In thoracic injuries two types of pneumothorax may be produced: (1) With an open wound of the thoracic wall; and (2) with a closed wound.

If a bilateral pneumothorax is present, the amount of collapse may produce death, due to the marked decrease of the vital capacity of the lungs. This condition demands immediate withdrawal of the air from both by a needle or a catheter.

Tension pneumothorax is a type of valvular pneumothorax, that is, the valvelike tear in the lung allows the air to enter the pleural cavity but prevents its escape. The closed type is seen in cases where the lung is ruptured by external compression when the glottis is closed. The symptoms are shock, cyanosis, dyspnea and shifting of the mediastinum. If the injury in the lung involves the mediastinal pleura, mediastinal emphysema may result, and progress to such an extent that crepitation can be felt in the suprasternal notch.

Tension pneumothorax can be rapidly fatal and should be treated immediately. The best and simplest method is the insertion of a large-gauge needle into the pleural cavity and thus allow the air to escape through the needle, which is connected to a rubber tube, the lower end of the tube being submerged in water two or three feet below the level of the bed.

Uncomplicated pneumothorax without tension requires no treatment other than keeping the patient semiupright in bed for a few days, because air is rapidly absorbed by the pleura.

Large open pneumothorax may result in death quickly, due to mediastinal flutter. The mediastinal flutter can be prevented during closure of the wound by steadyng the lung with forceps.

Blood may collect in one or both pleural cavities following any thoracic injury. Most penetrating wounds of the chest are followed by the accumulation of some blood in the pleural cavity, varying from an imperceptible amount to several liters. There are several sources from which the blood may come, the most frequent being from the injured lung. It may also come from severed intercostal vessels, internal mammary vessels, the azygos veins, the heart, or even from injured abdominal viscera if the diaphragm has been penetrated. The amount of collapse of the lung and, therefore, the amount of dyspnea depends upon the amount of blood and air in the pleural cavities. Many cases of hemothorax are accompanied by varying degrees of pneumothorax.

The treatment of hemothorax depends upon the amount of hemorrhage and its source. If the bleeding is from an intercostal or internal mammary

vessel, the vessel should be ligated immediately. If the hemorrhage is from the lung, bleeding will usually continue until the intrapleural pressure rises high enough to serve as a tamponade, which stops the bleeding.

If the amount of hemorrhage is not great enough to produce distressing respiratory symptoms and is not steadily increasing in amount, then it should be left alone. In such cases the patient should be placed in a semiupright position to facilitate respiration, and given sufficient morphine for rest. Morphine not only makes the patient more comfortable but is valuable in controlling further hemorrhage by decreasing physical and respiratory movements, thus allowing quicker clotting at the point of hemorrhage.

Whenever possible, the blood should be left in the chest. If the blood is withdrawn, the lung will reexpand and hemorrhage start anew. Instead of decreasing the chances of empyema developing, aspiration will increase the chances because it is an added avenue of entrance for bacteria. In over 95 per cent of the cases the blood is readily absorbed. The only indications for aspiration are severe dyspnea and pain.

If hemorrhage is sufficient to cause distressing respiratory difficulty, then thoracentesis must be performed and enough blood withdrawn to bring about comfort. It is best to replace the blood withdrawn with the same amount of air to maintain sufficient intrapleural pressure to prevent further hemorrhage from the injured lung. If hemorrhage persists in filling the chest, it may be necessary to cauterize the bleeding point through a thoracoscope, or the chest may have to be opened and the hemorrhage controlled with ligatures or packs. Several transfusions may be necessary.

Atelectasis may involve an entire lung, one lobe or a few lobules. Massive collapse results if a large bronchus becomes plugged. Following thoracic trauma, the atelectasis *per se* needs no treatment. When atelectasis is due to plugging of a bronchus, an attempt should be made to remove the plug by turning the patient from side to side, by giving expectorants, or with the aid of a bronchoscope.

Prolapse of the lung may occur in open, sucking wounds of the chest. If the lung is expelled through the wound as a result of a cough or severe strain, it may be caught by a fragment of a fractured rib. The lung tissue may be seen protruding through or into the wound. It is accompanied by pneumothorax, mediastinal flutter, and possibly some degree of hemothorax but usually in slight degree.

Treatment consists of holding the lung in the prolapsed position with sponge forceps, under hyperpressure anesthesia, while débridement of the wound is carried out and the lung is then cleaned and sutured. The external wound is closed tight. If drainage is necessary, it should be of the water-seal type.

Chylothorax results from damage to the thoracic duct as it passes through the mediastinum. It occurs infrequently and may easily be mistaken at first for empyema, as the fluid is gray and sanguineous. It appears one to three days following a chest injury and soon produces respiratory distress which rapidly

## INJURIES TO THE CHEST

requires aspiration. If the aspirated fluid is allowed to stand, it will separate into an upper milky and a lower bloody layer. Analysis of the fluid reveals fat to be present.

Treatment is chiefly that of repeated aspirations. The frequency of aspiration depends on the amount and occurrence of respiratory embarrassment.

Crushing injuries of the chest are frequently seen as a result of automobile accidents. Many are immediately fatal and are due to rupture of the heart, lungs or great vessels as a result of compression, or penetration of the viscera by sternum or broken ribs. Little attention has been paid to nonpenetrating heart lesions which are not fatal. Certainly, there is no reason to believe that the heart, situated as it is between the sternum and the spine, is not subject to contusions of considerable severity and from which recovery takes place in the majority of instances. The most common cause of such an injury is one in which the driver is suddenly thrown forward against the steering wheel, and the sudden compression may injure the heart without fracturing the sternum or ribs. Any patient who is struck in the chest should be suspected of such an injury, particularly if symptoms of precordial pain, dyspnea and tachycardia are present. Persistence of these symptoms, together with irregularity of the heart, cyanosis and a peculiar "tick-tick" quality of heart sounds, makes the diagnosis almost certain. The treatment is entirely symptomatic. The chief reliance is to be placed on morphine and sedatives for rest, and on oxygen for dyspnea and cyanosis. The patient should be confined to bed until all symptoms have subsided.

Penetrating wounds of the heart are usually produced by a stab or bullet. Occasionally freak accidents may result in penetration of the heart. Approximately 2 per cent of penetrating wounds of the chest injure the heart. If patients who die of cardiac wounds but never reach the hospital were considered, the percentage would probably be higher.

Symptoms of exhaustion, collapse, cessation of bleeding from the external wound, and frequently unconsciousness are due to tamponade and loss of blood. When the heart is wounded, it usually bleeds freely into the pleural cavity or to the outside. At the same time blood collects in the pericardial sac. When from 100 to 200 cc. has collected, the pericardium becomes distended, the intrapericardial pressure rises, and the venae cavae can no longer empty normal quantities of blood into the heart. The heart being unable to fill to capacity, can no longer empty, and cerebral anemia results.

To aid in the diagnosis the venous pressure should be taken and the heart viewed through the fluoroscope. Under the fluoroscope, the normally active cardiac shadow is seen to be motionless, or its amplitude greatly reduced. The normal venous pressure is 75 to 125 Mm. of water, but in cases of tamponade the venous pressure may rise as high as 340 Mm. of water and still be compatible with life, if the pressure is not maintained for too long a period.

In summary, a lowered or falling arterial pressure, a high or rising venous pressure, and the absence of cardiac pulsations by fluoroscopic examination make the diagnosis of tamponade practically certain.

The treatment is immediate operation. In order to save time, instruments needed for the operation should be kept ready at all times in a separate container. When the operation is begun, fluids should be started intravenously, but should be given slowly until the pericardium is opened and the tamponade is relieved. Transfusions of whole blood should be given to replace the lost blood. Autotransfusions are often life-saving. Several types of incisions have been advocated for approaching the heart, but the main aim is to secure its rapid exposure. The intercostochondral thoracotomy (Spangaro), with removal of one or more cartilages and a portion of the sternum, is probably the easiest and speediest. With any type of incision the internal mammary vessels are ligated and the lung and pleura are displaced outward by gauze dissection. Injury to the pleura should be avoided if possible. The pericardium should be opened, and the blood and clots aspirated. The wound in the heart can often be covered with a finger until a suture can be placed. It may require several sutures to close the perforation. After all blood and clots have been removed from the pericardium, it should be closed loosely in order to provide drainage of serum and residual blood into the pleural cavity. If the pleura has been damaged, an attempt should be made to repair it and the wound closed in layers. Silk is used throughout. Wounds of the right ventricle offer the best prognosis.

Perforation of the diaphragm, with or without abdominal injury, may result from various types of thoracic injuries and are probably more common than is realized. Unless there is an accompanying abdominal injury, many cases may go for weeks or even months before being recognized. Probably, many cases are never recognized if the perforation is small or incomplete.

There are no distinctive early symptoms unless there has been some abdominal damage. Later the symptoms of diaphragmatic hernia develop. Treatment is symptomatic. The chest injury must be treated, according to what damage has been done. If signs and symptoms of perforation of an abdominal viscous are found, an exploratory celiotomy must be performed and the damage repaired. Bullet wounds and wounds from long knives are the most common causes of thoraco-abdominal injuries.

#### SUMMARY

(I) The treatment of chest wounds is in the main conservative, directed toward: (1) The treatment of shock; (2) the arrest of hemorrhage and the replacement of lost blood; and (3) the restoration of the normal physiology and dynamics of the cardiorespiratory system.

(II) Active and immediate operative procedures are indicated in sucking wounds of the chest, persistent hemorrhage, tension pneumothorax and penetrating wounds of the heart.

DISCUSSION.—DR. A. O. SINGLETON (Galveston, Tex.): I shall direct my remarks to only one type of injury, and that is penetrating wounds of the heart. These wounds may be either gunshot or stab wounds. One of my associates, a young man who sees the humorous side of things very readily,

## INJURIES TO THE CHEST

says he can prognosticate the times by the wounds the Negroes have in our part of the country. In prosperous times they buy bullets—and gunshot wounds prevail, and in "hard times" they use a knife. At the present time we are not seeing so many stab wounds.

With stab wounds of the heart, the patient dies of one of two causes. He may die immediately, of course, but if he lives longer he will die of heart compression or from hemorrhage. The hemorrhage will be into the pleural cavity, the wound having penetrated the pleura and pericardium. Those who die of compression have a wound which did not penetrate the pleura. By the physical signs one can usually tell whether the patient had a thoracic wound of the heart or an extrathoracic one. Aspiration of the pleura and, if necessary, of the pericardium may be advisable. Where the pleura has not been soiled, it is important to avoid opening it when operating. Where the wound has penetrated the pericardium and the pleura, it is important to approach the heart through the pleura. By studying these cases I think one is able to determine fairly accurately when operative approach for suture of the heart is indicated.

**DR. DERYL HART** (Durham, N. C.) : In our experience, we have had little trouble with hemorrhage into the pleural cavity when the patient comes in shortly after the injury. Our most difficult problems have been in handling those patients who come in several weeks after receiving a puncture wound of the chest. The blood has not been evacuated, and the temperature is moderately elevated. Aspiration reveals an infection of a relatively low grade and subsequent roentgenograms show a multiloculated cavity, apparently formed by partial organization of the blood clot, occupying the pleural space left by the collapse of the lung. The problem of getting the lung to reexpand is far more difficult than in the usual empyema of a similar duration. It has seemed to me that in the presence of a large hemorrhage which has not been evacuated, the fibrosis and tying down of the lung is more rapid than in the presence of an acute empyema of like duration.

I wondered if Doctor Elkin has found that not evacuating a large hemorrhage predisposes to subsequent limitation of motion on that side of the chest, and also what experience he may have had with handling low-grade infections in partially organized hematomata of several weeks' duration.

**DR. I. A. BIGGER** (Richmond, Va.) : I enjoyed Doctor Elkin's paper and agree with most of the things he has said. However, there is some question in my mind in regard to his method of handling hemothorax. It has seemed to us that when there is a large amount of blood in the pleural cavity, even though there are no pressure symptoms, it is wise to evacuate it because of the value of the blood itself. If the patient is seen early and there is no evidence of gross contamination, you have an excellent supply of blood for autotransfusion. If the blood is aspirated within a few hours, I know of no reason why it should not be returned to the patient's circulation. Recently, Dr. H. J. Warthen, Jr., operated upon a patient for a heart wound which communicated with the left pleural cavity. Thirteen hundred cubic centimeters of blood were aspirated from the pleural cavity, citrated, filtered, and used for autotransfusion. We believe that this may have influenced the outcome. It does seem that if there is uncontaminated blood in the pleural cavity it should be aspirated and replaced by air. Simultaneous air replacement prevents the danger of reactivating the hemorrhage by changing the intrathoracic pressure.

One other point on which Doctor Elkin and I have previously disagreed is the question of aspiration in certain patients with acute cardiac tamponade,

a procedure which I believe Doctor Singleton first recommended. When patients with tamponade show a temporary response to conservative measures, relief of pressure by aspiration may prove to be the only treatment necessary. The very serious ones, who show less response to conservative measures, may be tided over by aspiration while adequate preparations are made for operation. In military practice aspiration should be of great value, for a large percentage of patients with heart wounds will die of tamponade before they can be transported to stations with adequate facilities for thoracotomy and cardiorrhaphy.

DR. DANIEL C. ELKIN (Atlanta, Ga., closing): In answer to Doctor Hart's question, there are certainly some cases in which, if blood is left in the chest, fibrosis and low-grade infection develop. These are difficult to cure. In some 1,500 cases of wounds of the chest we have had only 3 per cent infections—treated for the most part by conservative measures. I believe if all cases were aspirated or opened and cleansed of clots and fibrin and blood, infection would be high, and I think it is the lesser of two evils to treat them by aspiration unless symptoms of pain are present. If definite infection is present it must be treated as empyema. The question of aspirating to relieve compression of the heart by blood is an extremely difficult one to decide. Undoubtedly, there are some cases with definite tamponade of the heart, which if left alone will recover. Certainly, they could be cured by aspiration—but, how to choose these cases? Therefore, I think if these signs are present it is safer, in the long run, to operate and suture the heart.

## THE RÔLE OF THE PLASTIC SURGEON IN THE CARE OF WAR INJURIES\*

VILRAY P. BLAIR, M.D.

ST. LOUIS, MO.

FOR OUR PARTICIPATION in the World War, General Gorgas made definite provision to give special care to face and mouth wounds from the time of injury until final total restoration, as far as the latter was surgically and physically possible. This preparation embraced personnel and consultants, special equipment, and even dictated definite plans of procedure in cases where either the preservation of life or the possibility of ultimate rehabilitation might depend upon the kind of early treatment given, but all correlated to general plans of hospitalization, evacuation and transportation. Fortunately, the opportunity to use the plan was of short duration, but that the scheme was basically sound was proved by the fact that the majority of face and mouth injuries returning to this country as casualties had been wounded previous to St. Mihiel, before the plan could be put in anything like general operation. Though a much larger number of such injuries were sustained at St. Mihiel, the Argonne, and later, it is to be inferred from the records of the surgeon general, that the majority of the latter had been returned to duty before the time of embarkation.

In this country the care of these cases was rather indiscriminately referred to as "Plastic Surgery" or "the care of face and mouth wounds," but in the A.E.F. it was definitely classed as "Faciomaxillary Surgery," and it was because of their high percentage of occurrence in trench warfare that a special division was organized for their treatment. Many were almost immediately fatal, and most of those surviving who had not been given a correct start from the first were ambulatory for long periods, becoming indolent, resentful of discipline, and lacking in morale, while the government's policy of paying these men to remain idle proved far from helpful. In the aggregate, these became an immense expense to the government, and a small but vociferous minority were a "headache" to those assigned to their care. All of the above had been foreshadowed in the experiences of our Allies, but with us the difficulties were exaggerated both by the individualism of the American soldier and by well-meant but overenthusiastic expressions of civilian sympathy.

No special activity can survive in an army that is not smoothly geared to normal running of the whole scheme, which in action rates in importance first: men; then ammunition and food; the activities of the medical department coming fourth; therefore, it behooved that our division carry on inconspicuously.

To be welcome as well as useful in Front areas, Field and Mobile hospitals, it is more important that men designated for any special work be all 'round well-trained general surgeons than that they have any highly specialized know-

\* Read before the Fifty-third Annual Session of the Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

ledge of plastic surgery or any other special type of surgery. In a "putsch" in those days, operating surgeons in such hospitals were expected to work for 12-hour periods and to take on everything brought to their tables from fractured skulls to fractured toes, including all types of injuries anywhere in between. If they could not do this, they might prove more of a hindrance than a help.

The average dental surgeon has special knowledge of the treatment of jaw fractures. The well-trained surgeon is skilled in the care of the tissues of the whole body; by pairing these—a dentist and a doctor—into individual working units, we were eventually able to put the care of face and mouth injuries on a par with other standardized procedures. All we asked of those designated to care for face injuries in advanced areas was that they be familiar with a few simple working rules aimed at the preservation of life and tissue, that they call for and work with the dental surgeon on all jaw or face fractures whether open or simple, that each carry the needed simple special equipment in his *musette*, and, above all, that they never forget that they are under the orders of the commanding officer of the hospital wherever they might be even temporarily stationed.

The late care of these cases can best be undertaken in selected wards or hospitals where special skill and equipment are available, but these must be situated in the lines of evacuation. To reverse the stream of the latter, can be about as easy as reversing the flow of the Mississippi River. One of the pet schemes conceived in the office of the surgeon general, and sanctioned by the chief surgeon and by the chief dental surgeon of the A.E.F., was a hospital to be used for head and face injuries. This was finally located in one of the largest and newest hotels in Vichy, especially staffed and equipped, but, unfortunately, off the line of evacuation to the port of embarkation, with the result aptly pictured in the lament of the chief ophthalmologic surgeon who, ineffectually, objected to having his ward filled with leg and arm cases, protesting that, "except socially," he "had not seen a leg in 20 years."

Unless "digging-in" again becomes prevalent, faciomaxillary surgery will likely never again attain to the spotlight prominence it had acquired long before we got our cue of entry; however, the niceties of treatment which largely determine both the quality of the final result, and whether the recovery period will be measured by days, months, or possibly years, are still just as important to the individual casualty as if he were a battalion.

The above is a high-spot review of the impressions gained in seven months of preparation in the surgeon general's office, ten months of active duty in France previous to the Armistice, and 20 years of postwar caring for the injured—but all this would be meaningless did it not carry some possibly practical suggestions applicable to the future.

The type of surgery at present commonly designated as "plastic," is one of the oldest of the surgical arts, and has only an accidental relation to dentistry, or to any other surgical field. The machine age, more than war, has again emphasized and enlarged the need for this older type of surgery, and the call is being answered by men having, on the average, a little different

mental make-up than those who prefer to work in problems related to the special sense or the vital organs. Many of the same type of surgeons as those who responded to the call for Faciomaxillary Units have, in civilian practice, developed special skill for working in every part of the body, and in war surgery these could be just as economically and humanely valuable as in civil practice. There is a narrow or wide "no-man's-land" bordering



A



B

FIG. 1.—A female, age 29, had been deeply burned about chest, arms and neck by an explosion of stove polish, two and one-half months previously. In the meantime, she had been dressed with white vaseline and 2 per cent mercurochrome. (A) Shows patient's condition of absolute terror when she arrived at the hospital, and at that time she weighed 83 lbs. Her first six dressings were done under gas anesthesia, and later, piece-meal inch-square grafts were applied to the uncut granulations at intervals. Each piece of graft was held firm by a suture anchored in the deep scar and tied over an individual small wad of gauze. All together, at different admissions, she was in and out of the hospital for a period of 15 months, and that she recovered is a tribute to the skill, kindness and perseverance of Dr. Kenneth Lewis, who at that time was a dresser on our service. (B) A photograph of the patient sent to us some time later.

most all special fields in surgery which is apt to be shunned by the men working on either side. It is in these "no-man's areas" of the body surface that the basically trained plastic surgeon can make himself really useful. As one example, let me cite the late care of large third degree burns, which were quite common both in field and naval engagements. After a few weeks, such a patient is no longer suffering from a burn but from a usually infected surface wound, which if left to the natural repair devices may be months in healing, or complete closure may never occur; in the meantime both vital and motor function being imperiled by both infection and excessive scar, while physical and mental suffering (Fig. 1), and the economic drain may be of any extent (Fig. 2). Yet by proper restorative surgery most all of this can be avoided and the recovery period reduced from years to weeks.

It is interesting to look back to the discussions, the literature, and the treatment we observed of major burn cases in the World War; almost the whole problem seemed to be to evolve a dressing that would protect and encourage the slow process of healing by the ingrowth of epithelium upon

the granulation, but never the early elimination of the wound and symptoms by massive skin grafting. The skilled plastic surgeon should be able to sharpen an old-fashioned razor and cut 100 square inches of split-skin graft in a relatively short time, and he should, on the average, be best suited to



FIG. 2.—A man, age 27, had been deeply burned on the backs and sides of both thighs and legs, 18 months previously. (A) Shows the condition at the time of our first examination: There being partial backward subluxation of both tibiae, with a flexion deformity of 30°. Owing to the joint deformity and an intercurrent acute appendix, it was 60 days before the left limb was grafted, and the right was done 30 days later. (B) Shows the condition 15 days after the right side was grafted. A year later the scar on the right limb broke down above the original graft and required further grafting. From the economic standpoint, this case was of special interest, he and the family having reported that they spent more than \$1,200 for a widely advertised burn ointment in addition to dressings during the 18 months before the grafts were applied.

do the work. In the proposal that the *late* care of extensive burns be turned over to plastic surgical units, I am not suggesting infringement on the field of the general or any other surgeon, but it is just a suggestion to prevent these large deep burn cases from becoming surgical "junk," which too often happens. In this regard, conditions in civil practice appear to be nothing to boast of. During the 20 years following the armistice, Dr. James Barrett Brown, Dr. Louis T. Byars, and the writer treated 340 late burn injuries that had remained unhealed or continued to be an inconvenience or crippling for periods varying from three months to an ordinary lifetime after occurrence of the injury (Fig. 3). The average time that had elapsed between injury and inauguration of surgical repair was 5.1 years. The aggregate period of disability in this group from the time of injury until final discharge was

2,312 years, or an average of 6.8 years for each case. These required 1,037 repair operations, with an average treatment and observation period of 1.7 years per case (Figs. 4 and 5). From our experience in the earlier care of deep burns of similar extent, it seems fair to assume that with more con-



FIG. 3.—A male, age 31, had been burned at age 16, by a live wire. For the past two weeks he had had an open ulcer in the scar at the elbow. He had received \$40,000-\$50,000 in compensation, but when he came to us he was on relief. The ulcer proved to be a carcinoma developing in the scar. (A) Shows the condition at our first examination. (B) Shows the condition seven months after a wide excision of the ulcer, the arm having been freed in such a way that its raw surface could be almost completely covered from the chest flaps that remained attached to it. The raw surface was covered with split-skin grafts as shown. He ultimately died from recurrence of the carcinoma.

structive treatment the great majority of the above 340 cases could have been successfully restored to approximately normal function and acceptable appearance within three months from the time of injury, with half the number of repair operations and very much better average results than was possible with these late-treated cases (Figs. 6 and 7). Reducing the average disability period for each of the above late-treated cases from 6.8 years to the estimated average of three months per properly early-treated case would reduce the total disability period of the whole group from 2,312 years to 82 years.

DISCUSSION.—DR. ROBERT H. IVY (Philadelphia, Pa.): It is a great privilege to be invited here to discuss Doctor Blair's paper. I had the honor of assisting him in the preparation of the plans for care of these injuries during the late war, and that experience has been of great help to me in my own work and in helping formulate plans for what may happen in the future.

I believe the theory of keeping in mind the broader aspect of this field is sound; that is, that it embraces plastic repair of injuries all over the body and that it is not limited to face injuries. This comprehensive view has not been lost sight of in the surgeon-general's office and the special committees formed by the National Research Council. There are, however,

A



B

FIG. 4.—A female, age 23, had been in a gasoline explosion, two years previously, and, among other injuries, seemed to have lost all of the skin of both hands except in the cleft between the left thumb and index finger and also some extensor tendons. Six months later the right thumb and one finger on the left hand had been freed by simple incision, without grafting, but, naturally, the new clefts became obliterated in the healing. (A) Shows the condition when patient came to us—with only the left thumb free; and it, also, shows how she was able to write. (B) Shows the condition of the right hand two months later—the three clefts having been established with full-thickness skin grafts. Also, the lost soft tissues of the back of the left hand and fingers had been replaced by a pocket-graft from the left thigh, preliminary to restoring the three inner clefts. She did not return for completion of the work. A letter received six months later states: "My hands are doing nicely. I can do almost everything I wish."



FIG. 5.—A female, age 38, had had a mangle burn, eight months previously, which, evidently, was not much deeper than the skin, as the extensor tendons appeared to be intact. This was allowed to heal naturally. (A) Shows the condition at the time of our first examination. The metacarpophalangeal joints seemed to be intact, but the interphalangeal joints of the second, third and fourth fingers were fixed. The scar was dissected from the back of the hand and four inner fingers, and the hand and fingers placed in a glove-shaped subcutaneous pocket in the upper part of the left thigh, and later removed; the clefts established; and the borders of the flaps sutured to the hand and fingers; and the fingers dressed in a semiflexed position over the end of a padded splint. A month after the flap was sutured in place, the spring traction splint shown in (B) was put in use, but it failed to reestablish movement at the proximal interphalangeal joints of the index and middle fingers. Later, the distal ends of the proximal phalanges were removed to establish false joints. (C) and (D) Show the appearance and amount of movement ultimately gained six years after our first treatment. It is most likely that a skin graft applied three or four weeks after the burn was received, would have forestalled the periartricular fixation, and the glove-pocket flap applied soon after healing would have given a quick recovery with no joint fixation.

certain special features to be remembered in connection with face injuries, and the general surgeon should realize that cooperation with the dental surgeon is of utmost importance. The ideas started by Doctor Blair during the last war will be fully utilized in plans which are being formulated for the treatment of these injuries in future wars.



FIG. 6.



FIG. 7A.



FIG. 7B.

FIG. 6.—A male, age 60, was burned by being pinned under an overturned tractor for one hour and 45 minutes, with the muffler in contact with his left flank and back. It was found that the burn extended to the muscles and crest of the ilium. The area was partially débrided and wet dressings applied. Five weeks later the whole area, which was more than a square foot in extent, was covered with split-skin grafts, excepting a protruding burned part of the crest of the ilium. The photograph was taken two months after the injury, and three weeks after he grafts were applied. At this time, the patient went back to his job as a farm superintendent, still wearing a dressing over the protruding burned bone.

FIG. 7.—A male, age 42, had been burned by his clothing catching fire, 32 years previously. He was burned from knee to shoulder on the right side. Over the right buttock and thigh there was a large area of hard scar, which had broken down repeatedly. At the time of our examination there was an ulcer, 4x5 inches, that had been open for two and one-half years as shown in (A). This raw area was dissected out widely, including much thick surrounding scar, leaving a defect twice as large as the ulcer. This was covered with split-skin grafts which took completely. (B) A photograph, 42 days later, shows the extent of the graft. A letter, received one year later, reported a perfectly satisfactory result. The microscopic examination of the tissue removed from the ulcer border showed chronic inflammation.

The principal points in face and jaw injuries to be stressed at advanced posts, where there are no specialists or where the assignments are general are, first of all, arrest of hemorrhage. The second point is the establishment of proper airway, by holding the tongue forward with a suture, or passing a rubber tube back to the throat through the nose, or by placing an appliance to hold the collapsed jaw bones forward. The third thing is temporary fixation of the jaw fracture by emergency appliances before any attempt is made at closing the wound. Doctor Blair spoke about not closing the soft tissues over a fracture. It is important to reduce and fix the bone fragments and later close the soft tissues. The fourth thing is provision for safe transportation. These faciomaxillary cases should be sitting up if possible. If they have to be recumbent on a litter, they should be on the face, not on the back, and in that way many lives will be saved.

## NEW DEVELOPMENTS IN THE TREATMENT OF COMPOUND FRACTURES\*

GUY A. CALDWELL, M.D.

NEW ORLEANS, LA.

FROM DIVISION OF ORTHOPEDICS, DEPARTMENT OF SURGERY, SCHOOL OF MEDICINE, TULANE UNIVERSITY,  
NEW ORLEANS, LA.

THE POSSIBILITY of participation in hostilities, as well as the ever-increasing number of traffic and industrial accidents, has stimulated renewed interest in the treatment of compound fractures. Basic principles of treatment remain unaltered, but various modifications of details have been suggested with increasing frequency during the last two or three years. Some of these variations in treatment are fundamentally sound, whereas many others, based on unreliable statistics, are misleading.

The failure of analyzers of series of cases, when reporting upon methods of wound treatment, to differentiate between soil-contaminated compound fractures, with much tissue damage, and those fractures produced by indirect violence, with only a small puncture wound, has only added to our confusion of the subject. Approximately 300 compound fracture cases were seen at Charity Hospital in New Orleans during 1939-1940. I recently reviewed these in regard to treatment for prevention of gas gangrene. Of these 300, only 187 had fractures of the long bones, and after eliminating those that died of other causes within 24 hours, those received late, and those with small punctured wounds, there remained only 20 cases of truly soil-contaminated, recent compound fractures suitable for analysis with reference to treatment. Conclusions concerning the occurrence of gas gangrene based upon all of the compound fractures, or even all cases involving the long bones, would have been most inaccurate. The statistics offered as evidence of the value of roentgenotherapy and chemotherapy in treating the complication of gas gangrene, without indicating whether or not surgical measures were employed concomitantly with these procedures, have left us in doubt as to their value.

The fundamental importance of adequate splinting of compound fractures where the injury occurs remains unchallenged. Opinions vary, however, as to the advisability of drawing a dirty, projecting fragment of bone back into the tissues when applying a fixed traction splint for transportation. Since it is universally agreed that all of these fractures must be débrided when they arrive at an hospital, and that traction splints, properly applied, provide maximum fixation and protection in transit, there can be no valid reason for failure to employ them when they are available.

The patient's general condition continues to be our first consideration in the management of compound fractures. Because of the investigations of

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

John Scudder,<sup>1</sup> and others, it is now possible, by simple measures, to estimate dehydration accurately and promptly, and to determine whether or not the administered fluids are being utilized sufficiently. In addition to these valuable contributions to the control of shock, the development of blood banks and, more recently, of pooled plasma, make it feasible to relieve severely shocked patients promptly. So great is the possibility of rallying these patients, whose shock is the direct result of compound fractures of the extremities, that Murray<sup>2</sup> recently stated: "If shock treatment is adequate, infusion, transfusion, cortin, *etc.*—there is no reason why the patient cannot go to the operating room, where his débridement is performed, while shock treatment is being carried out." Many will not be as sure as Murray of the efficacy of their measures to control shock, but no one will deny that every hour that can be gained in performing early débridements will diminish the incidence of serious infections and, coupled with other measures of chemotherapy now available, make more possible the use of internal fixation and the closure of wounds in selected cases.

Administration of combined antitoxins for tetanus and gas gangrene has become almost a routine procedure in the emergency rooms of all hospitals receiving compound fractures. Recent developments in the use of tetanus toxoid<sup>3</sup> indicate that it is practical and efficacious in preventing tetanus. It is probable that all army recruits will be thus immunized, and that in the future children will receive tetanus and diphtheria toxoid together. The efficacy of gas gangrene antitoxin as a prophylactic measure has never been generally accepted. With earlier and more efficient débridement, and the possibilities of chemotherapy in preventing wound infections, gas gangrene antitoxin may eventually be omitted as a routine preventive measure. In civil practice, however, the combined sera will doubtless be continued for some years.

The best manner of preparing the skin and the wound for operation has been a controversial question for years. Most American surgeons<sup>4, 5, 6, 7</sup> favor shaving and washing the skin with soap and water, and subsequently irrigating the wound abundantly with saline and sterile water. Boehler,<sup>8</sup> and Watson-Jones<sup>9</sup> emphasize, on the contrary, the importance of avoiding extensive skin preparation and the use of irrigating solutions during and following operation. They rely rather upon cleansing the immediate wound area with ether or painting it with iodine, and removing all foreign material from the wound by meticulous dissection through a wide exposure, under good light. Under military conditions the latter method will probably be the accepted one, and should, therefore, be adopted in training centers.

Too little attention has generally been given to maintaining immobilization of the fracture during the period of skin preparation, draping and operation. Among others, Winnett Orr,<sup>10</sup> and Watson-Jones<sup>9</sup> emphasize the importance of transferring the fractured extremity from the transportation splint directly to the traction devices of a fracture table before preparation of the skin and operation are undertaken. When transfixion of the fragments above and below with Steinmann pins is the desirable method for postoperative fixation,

## TREATMENT OF COMPOUND FRACTURES

the whole procedure can be simplified by first inserting the pins, attaching the limb to a traction device, and then proceeding with the skin preparation and operation.

Whereas the use of strong antiseptics in the wound is generally condemned and even irrigation with bland solutions is considered undesirable, there is an increasing tendency to implant crystals of sulfanilamide into the débrided wound rather than to depend upon administration of the drug orally or parenterally following operation. Key<sup>11</sup> has reported experimental and clinical observations indicating that the drug does not injure tissues nor joint structures, and does not interfere with healing or union. Jensen, *et al.*<sup>12</sup> were able to lower the incidence of infection in compound wounds treated by early débridement and implantation of sulfanilamide crystals in the wound. Bohlman,<sup>13</sup> and Johnson<sup>14</sup> believe that this compound prevents and controls gas gangrene infections. Watson-Jones,<sup>15</sup> in a personal communication of July, 1940, stated: "Prophylactic chemotherapy has been employed in compound and gunshot fractures for a considerable time, but I believe that it is still too soon to judge the relative merits of sulfanilamide melted into the wound, and the same preparation given by mouth or injection, and also too soon to know how much better prophylactic chemotherapy may be than chemotherapy instituted at the first sign of infection."

I<sup>16</sup> performed some experiments on guinea-pigs, injecting lethal doses of *C. welchii* in thigh wounds, débrided them early, implanted sulfanilamide crystals, and closed the wounds. Most of these animals died with gas gangrene; whereas, in another series, in which the wounds were débrided early and left open, and sulfanilamide was injected intraperitoneally, most of the animals survived and few had gas gangrene.

*Implantation of Sulfanilamide Crystals*

Nineteen guinea-pigs, routine preparation; from one to six hours after inoculation—débridement; implantation of 15-30 mg. sulfanilamide crystals; suture. Eight controls.

Results: Died, 6-48 hours .....	15
Lived .....	4
Controls died, 14-86 hours .....	8

*Gas Gangrene Experiments*

Wounds of nine guinea-pigs débrided at two hours and left open. Sulfanilamide by intraperitoneal injection.

Results: Lived .....	7
Died .....	2

Two Controls, débrided and left open:

Lived .....	1
Died .....	1

These experiments suggest that we should be wary of closing the wounds after débridement in cases with extensive tissue damage and soil contamination, even when sulfanilamide can be melted into them or administered by mouth.

Fragmentary reports from surgeons<sup>17, 18</sup> who worked in Spain, and in

Finland during recent wars, indicate that they were unable to close the wounds in many cases even when sulfanilamide could be given. They also report a very low incidence of gas gangrene. Whereas sulfanilamide is a valuable adjunct to débridement in the prevention of serious wound infections, it is, at best, only a bacteriostatic agent (not bactericidal) which is less effective against the anaerobes than against other organisms. Therefore, wounds laden with organisms from fertilized soil should be sutured with great hesitancy.

Extensive lacerations over subcutaneous bones, such as the tibia, may be sutured provided counterincisions of adequate length are made elsewhere through the skin and deep fascia, extending down to the site of fracture. Wounds of the joints may be débrided, lavaged and sutured as a rule, even in the presence of gross dirt, because the joint structures provide a poor culture medium for the propagation of gas bacilli.

Internal fixation of the fracture following débridement can be, and has been, safely performed in those patients whose general condition is good if they are seen within a few hours, after incurrence of a compound fracture of the leg or arm, by a competent surgeon and good assistants who have a complete armamentarium of instruments, plates and screws of Vitallium, together with sulfanilamide. Although this is the ideal method of securing that perfect immobilization essential to prevention of the development of infection, the conditions described are seldom encountered, especially on or near a battlefield. Recourse must, therefore, be taken to those appliances which permit the maintenance of alignment and approximation of fragments at the same time that the wound is being dressed.

Encasement of the limb in closed plaster, with the wound open, does not prevent the escape of odors that are discouraging to both patient and physician. Frequent dressing of the wound with strong chemicals, or copious irrigations through small windows in the plaster, undoubtedly retard healing. However, in most cases, it is possible, by exercising some ingenuity, to maintain adequate fixation and alignment while retaining sufficient exposure of the wound to change dressings, cleanse the skin margins, and carefully apply bland ointments. When this is done the wound heals rapidly, the patient is more comfortable, and the atmosphere of the hospital ceases to be reminiscent of the days before Lister and Pasteur. The recent advent of pectin and its combination with sulfathiazole, suggested by Thomson,<sup>19</sup> makes possible a thin jellylike ointment which, in our hands, has eliminated the odors from nearly all pyogenic wounds communicating with bone, has rapidly diminished the quantity of purulent discharge, and has produced healthy granulations and earlier healing than we have observed with any other type of dressing.

The most dreaded complication of soil-contaminated compound fractures is gas gangrene. Anaerobic culture of all the excised tissue removed when the wound is débrided, as recommended by Meleney,<sup>18</sup> determines the presence of *C. welchii*, thus enabling the surgeon to be alert to the development of early symptoms. If excessive pain and swelling occur within 24 to 36

## TREATMENT OF COMPOUND FRACTURES

hours, the wound should be dressed and the surgeon should look for the typical brick-red, watery discharge, with the unmistakable pungent odor that is so characteristic in gas gangrene. These signs are usually easily observed before there is roentgenologic evidence of gas in the muscle layers. At this stage, administration of large doses of gas gangrene antitoxin and sulfanilamide by mouth until the blood level is high, extensive incisions of skin and fascia, with excision of the entire length of involved muscles, and the application of zinc peroxide paste to the open wound, probably offer the best means of arresting progress of the disease. If the wound is below the knee or elbow, these measures instituted early will usually suffice, but if there is extensive involvement in the midthigh or upper arm, the prognosis, at best, is poor. If further progress of the disease is noted within 12 to 24 hours after operation, disarticulation at the knee or elbow is the only safe procedure.

The claims of some radiologists<sup>21</sup> and surgeons that roentgenotherapy is a valuable prophylactic measure, that roentgenograms reveal the earliest evidence of the infection, and that further roentgenotherapy will arrest progress of the infection, especially when chemotherapy and surgical measures are carefully omitted, constitute dangerous propaganda. These suggestions originate from enthusiasts and faddists, whose conclusions have been based on incomplete analyses and careless observations of scattered groups of clinical cases. Review of their tabulated reports suggests that, in many instances, the cases are not true clinical manifestations of gas gangrene, that the time-honored and proved measures of surgery and therapy that have been used in conjunction with roentgenotherapy have not been considered, and that experimental work to support the efficacy of irradiation is altogether lacking.

In connection with other experiments on treatment of gas gangrene Cox and I have produced gas gangrene in the thigh wounds of guinea-pigs, and have subjected them to varying doses of roentgenotherapy at intervals of one to five hours after inoculation. In no case has it been possible to arrest the progress of the disease in closed wounds by the use of roentgenotherapy.

*Gas Gangrene Experiments*

Two drill-holes in femur; 0.15 cc. broth culture *C. welchii* implanted, wound closed primarily; irradiation one hour later.

Number of Pigs	Total Dosage	Avg. Time Survival
10	35 r.	41.4 hrs.
10	150 r.	40.6 hrs.
10	400 r.	25.4 hrs.
10	100 r.	32.9 hrs.
10 controls		25.6 hrs.

Although the experiments suggest that progress of the infection is retarded, they also indicate, paradoxically enough, that the smaller the dosage the better the effect. We have noted that roentgenotherapy in small doses at frequent intervals, is *not* sufficient to arrest a massive, early infection, does not even retard the fully developed infection, and is not more effective

than chemotherapy alone. These findings suggest that a surgeon would not be justified in subjecting a person with suspected or proved gas gangrene infection to roentgenotherapy to the exclusion of all other methods of treatment.

#### CONCLUSIONS

Reports in the literature pertaining to roentgeno- and chemotherapy which fail to consider all the factors concerned are not reliable.

Improved methods of estimating the degree of shock and loss of body fluids together with more prompt and efficient treatment make possible earlier débridement of compound fractures. The incidence of infections can, therefore, be diminished.

Tetanus antitoxin, as a preventive measure, will disappear as more of the military and civil population are immunized with tetanus toxoid.

Extensive preparation of the skin and wound with soap and water could be replaced by ether or iodine.

Immobilization of the fractured parts by traction during the stages of preparation and operation is desirable.

Implantation of sulfanilamide crystals in compound wounds is a valuable adjunct in preventing infection. Animal experimentation indicates that it has relatively little effect upon the progress of gas gangrene in closed wounds infected with *C. welchii*.

Internal fixation of fragments followed by closure is safe only in carefully selected cases operated upon by competent surgeons who possess a good armamentarium of instruments and equipment.

Postoperative fixation of open fractures in closed plaster encasements is objectionable and unnecessary. Adequate fixation which permits careful dressings can always be devised.

Sulfathiazole in pectin jelly forms ideal bland substance for dressing these wounds—it eliminates the odors, reduces the amount of discharge, and hastens healing.

The complication of gas gangrene can be recognized before it is revealed roentgenologically. The treatment is essentially surgical, with the use of sulfanilamide and antitoxin as adjuncts.

Roentgenotherapy, alone, has not yet proven its usefulness as a measure for arresting the progress of gas gangrene. Experimental work suggests that it has some inhibitory action under certain conditions.

#### REFERENCES

- <sup>1</sup> Scudder, John: Shock; Blood Studies as a Guide to Therapy. J. B. Lippincott Co., Philadelphia and New York. 1940, p. 181.
- <sup>2</sup> Murray, Clay Ray: In discussion of Heyl, J. H.: Compound Fractures of Long Bones. ANNALS OF SURGERY, 11, 470, March, 1940.
- <sup>3</sup> Rogers, R. P.: The Use of Tetanus Toxoid in Private Practice. Bull. New York Acad. Med., 15, 553, August, 1939.
- <sup>4</sup> Felcetti, J. C.: Compound Fractures. Med. Times, New York, 66, 472, October, 1938.

## TREATMENT OF COMPOUND FRACTURES

- <sup>5</sup> Key, J. A., and Conwell, H. E.: The Management of Fractures, Dislocations and Sprains. 2nd ed., C. V. Mosby Co. St. Louis, 1937, p. 155.
- <sup>6</sup> McMaster, P. E.: The Principles of Treatment of Compound Fractures. Am. Jour. Surg., **38**, 468, December, 1937.
- <sup>7</sup> Ritter, H. H.: The Management of Compound Fractures. Arch. Surg., **34**, 527, March, 1937.
- <sup>8</sup> Boehler, L.: Treatment of Fractures. Wilhelm Maudrick, Vienna, 1929, p. 45.
- <sup>9</sup> Watson-Jones, R.: Fractures and Other Bone and Joint Injuries. E. and S. Livingston. Edinburgh, 1940, p. 143.
- <sup>10</sup> Orr, H. Winnett: Wound Infection and Compound Fractures. Illinois Med. Jour., **76**, 71, July, 1939.
- <sup>11</sup> Key, J. A., and Burford, T. H.: The Local Implantation of Sulfanilamide in Compound Fractures: Its Effects on Healing. South. Med. Jour., **33**, 449, May, 1940.
- <sup>12</sup> Jensen, N. K., Johnsrud, L. W., and Nelson, M. C.: The Local Implantation of Sulfanilamide in Compound Fractures. Surgery, **6**, 1, July, 1939.
- <sup>13</sup> Bohlman, H. R.: In discussion of Trueta.<sup>17</sup>
- <sup>14</sup> Johnson, R. W.: In discussion of Trueta.<sup>17</sup>
- <sup>15</sup> Watson-Jones, R.: Personal communication.
- <sup>16</sup> Caldwell, Guy A.: Treatment of Gas Gangrene Experimentally Produced. In press.
- <sup>17</sup> Trueta, J.: The Treatment of War Fractures by the Closed Method. Brit. Med. Jour., **2**, 1073, December 2, 1939; Also Proc. Roy. Soc. Med., **33**, 65, November, 1939.
- <sup>18</sup> Odelberg, Axel: Surgical War Experiences. Nord. med., **5**, 551, March 23, 1940.
- <sup>19</sup> Thomson, J. E. M.: The Ten Commandments for the Treatment of Compound Fractures. J.A.M.A., **115**, 1855, November 30, 1940.
- <sup>20</sup> Meleney, F. L., and Johnson, B.: The Prophylactic and Active Treatment of Surgical Infections with Zinc Peroxide. Surg., Gynec., and Obstet., **64**, No. 2A, 387, February, 1937.
- <sup>21</sup> Kelly, J. F., and Dowell, D. A.: Roentgen Treatment of Gas Gangrene. Arch. Phys. Ther., **20**, 88, February, 1939.

## WAR WOUNDS OF THE NERVOUS SYSTEM\*

CLAUDE C. COLEMAN, M.D.

RICHMOND, VA.

FROM THE DEPARTMENT OF NEUROLOGICAL SURGERY, MEDICAL COLLEGE OF VIRGINIA, RICHMOND, VA.

INFORMATION is not yet available for definite statements as to the incidence or character of injuries of the nervous system in the present war. Scant consideration has been given to injuries not caused by penetrating missiles in the medical records of previous wars for the obvious reason that such injuries were few in number compared with those produced by bullets, shrapnel and shell fragments. The traditional medical attitude that penetration is characteristic of war trauma was justified by past experience; but warfare is now waged by mechanized equipment and this is conducive to the production of injuries similar to those of transportation and industrial accidents in civil life.

An important activity of the present conflict is the aerial bombing of thickly populated areas of the belligerent countries, producing the greatest number of casualties among the civilian population. The bombing of cities will inevitably inflict serious injuries of the nonpenetrating type. The ratio of open wounds to closed injuries may show fluctuation according to the agencies and methods of military action. Many different types of injuries of the nervous system among the civilian population as well as the combatant forces will require the services of the modern army neurologic surgeon.

In the First World War, injuries to the nervous system were numerous, while the number of surgeons qualified to treat such injuries was small. During the past 20 years the field of neurologic surgery has developed rapidly, and with this development there has come a better appreciation and wider understanding among the medical profession of the problems of surgical neurology. The principles of treatment of injuries of the nervous system established during the First World War, with the added experience in the management of many thousands of injuries resulting from transportation and industrial accidents during the past two decades, can readily be applied to similar injuries produced in modern warfare.

In view of the voluminous literature on the management of closed injuries of the head and spine appearing since 1920, it seems unnecessary to make any reference to such injuries in this discussion, although injuries of this type may be numerous in modern warfare. Penetrating wounds of the brain and spinal cord are by no means rare in civil life, but since the appearance of the medical records of the First World War the literature has made little reference to such injuries. The purpose of this communication is to recall briefly the principles of treatment found to be effective in the manage-

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 1940.

ment of wounds of the nervous system in the First World War, with some discussion of the advances made through the application of these principles to similar injuries in civil life.

In a review of statistics of the last war, it is shown that of the patients reaching hospitals in one of the belligerent countries, approximately 25 per cent presented neurologic problems of one kind or another. Among the 174,296 battle injuries in the American Expeditionary Forces reaching hospitals, the head alone was involved in about 6 per cent, and of these, about 11 per cent resulted fatally. The delay in surgical treatment of penetrating wounds of the head, and lack of unanimity of opinion as to the best method of treatment were important factors in the mortality of casualties involving the head alone in the early period of the war. Another important factor in the mortality of head wounds was the frequent association of severe injuries in other parts of the body. In the early part of the First World War the operative mortality of gunshot wounds of the brain was about 60 per cent. This mortality was reduced to about 28 per cent by the operative methods advocated by Dr. Harvey Cushing. There has been no modification of importance in this technic of operation for gunshot wounds of the brain received either in warfare or in civil life since it was first proposed by Doctor Cushing.

War as waged to-day by some of the involved nations produces the greatest number of casualties at or near well-equipped hospitals, thus making possible early and adequate treatment regardless of the nature of the injury. The facilities for early and complete care of head injuries should be provided as far as possible in all phases of military operations, leaving only the very minor types of injury or those in shock to be cared for at the front line posts or First Aid Stations. Prompt transportation by airplane of soldiers with gunshot wounds of the head in field operations has been successfully used in some of the countries now engaged in war. In this connection, it has been stated that open wounds of the brain do not well tolerate elevation of more than 5,000 feet. Experience has shown that patients with head injury, when not in shock, stand ordinary transportation very well, and this also applies to patients in good postoperative condition. While every effort should be made to provide early operation upon penetrating wounds of the brain, a delayed operation at a station or hospital where complete surgical treatment can be provided is much better than an early inadequate operation. Adequate treatment of head injuries at advanced posts when transportation to a completely equipped hospital is impracticable may be provided by means of motorized surgical units. The prompt transfer of patients to base hospitals or the competent treatment at advanced posts by trained neurologic surgeons should bring about a definite reduction in the mortality of head injuries.

*Open Wounds of the Brain.*—Too much emphasis, perhaps, has been given to a time limit for operations on open wounds of the brain. It is highly desirable that these wounds should be operated upon within 16 hours if possible. However, many cases may be operated upon to advantage as

late as 48 hours or more, if obvious infection is not present. It is reasonable to expect that chemotherapy, promptly instituted in penetrating wounds of the brain, will increase the number of cases that may be benefited by later operation, and that the incidence of severe intracranial infection will be reduced by chemotherapy in all cases.

The treatment of head wounds at First Aid Posts should be limited to the control of external hemorrhage, treatment of shock, shaving the scalp, irrigation of the wound with saline or Ringer's solution, followed by the application of a sterile dressing and the administration of prophylactic tetanus antitoxin and some of the sulfonamide compounds. No effort should be made to remove bone fragments or other debris unless they lie loosely in the wound. Simple laceration of the scalp may be débrided and sutured at the First Aid Station provided there is no involvement of the skull and no evidence of intracranial injury.

When the patient with a penetrating wound of the head has been placed under conditions suitable for complete investigation, careful neurologic examination should be made, and the entire head shaved. There may be multiple bullet wounds of the scalp and each should be considered a potential brain wound until otherwise disproved. Tangential or gutter wounds of the skull are especially liable to cause severe brain damage by shattering fragments from the inner table of the skull. These fragments often penetrate the brain for a considerable depth. The effect upon the skull and the location of intracranial foreign bodies, such as indrawn bone or metallic fragments, should be shown by roentgenograms, and the number of these foreign bodies checked with the number removed at subsequent operation. Restless patients may be given morphine preliminary to the use of local anesthesia by novocain injection of the scalp. Local anesthesia should be employed in every case if practicable. Sometimes the treatment of shock and the intracranial operation may be carried out simultaneously.

The fundamental objective in the treatment of penetrating wounds of the brain is the prevention of infection. Disinfection of a penetrating wound is accomplished by copious irrigation of the wound with saline or Ringer's solution, excision of the edges of the scalp wound, and careful removal of bone fragments, macerated brain tissue, blood clot, and foreign bodies whenever practicable. Chemical disinfection of fresh wounds should be discontinued in view of the superior results from mechanical disinfection with large quantities of saline solution. It may be necessary to enlarge the scalp wound by incisions, in order to give better exposure of the underlying wound of the skull and brain. Slight enlargement of the bone defect may be required, but it seems unnecessary to remove the fragments *en bloc*, unless the depressed fragments lie directly over one of the large venous sinuses. After removal of the bone fragments the wound should again be thoroughly irrigated. Large quantities of solution are required for thorough cleansing of these wounds. Macerated brain tissue is removed by irrigation through a catheter attached to a bulb syringe, supplemented by gentle suction through

## WOUNDS OF NERVOUS SYSTEM

a bent glass tube attached to the suction tip. By the use of irrigation and suction, alternately, the macerated brain tissue, blood clot and foreign bodies may be removed. Missiles which have passed beyond the midline of the skull from the point of entrance may be removed through a trephine opening made at a point most accessible to the missile, as shown roentgenologically. It may be possible, after removing the missile in this way, to effect a through-and-through irrigation for complete cleansing of the brain wound. Removal of débris from the brain wound will usually permit inspection of its depths, provided hemorrhage has been controlled and infection has not developed. Great care must be exercised in following the track of the bullet, in order to prevent further injury to brain tissue, and, in many cases, to avoid penetration of the ventricles. The devitalized brain tissue should be removed by suction down to the limits of normal brain. All foreign bodies should be removed when accessible, providing this is compatible with the protection of important functional areas. Bleeding vessels may be drawn up into the suction tip and coagulated with the electrosurgical unit, under direct inspection, made possible by the use of the lighted spatula. The addition of the suction apparatus and coagulation unit to the surgical equipment will do much to facilitate complete operation in penetrating wounds of the brain and to lower mortality. After thorough cleansing and complete hemostasis, the brain defect is filled with Ringer's solution. The dura should be closed securely without drainage unless there is some doubt as to the completeness of disinfection. The scalp is closed in layers, using interrupted fine silk sutures. Drainage of the scalp wound is unnecessary.

When there is evidence of infection the operation must, of necessity, be a limited one. Easily accessible bone fragments may be removed, the opening in the dura enlarged and drainage provided. The scalp wound should be packed with vaselinized gauze, and not sutured. The resulting brain fungus should be protected by a rubber dam over which is placed a doughnut ring of gauze.

The prevention of infection by thorough removal of devitalized brain tissue, blood clot and foreign bodies will minimize the subsequent scar tissue formation, thus decreasing the chances of epilepsy.

The surgical management of compound fractures of the skull with dural laceration is similar in principle to that of penetrating gunshot wounds of the brain. Reliance is placed upon careful mechanical disinfection of the wound with thorough débridement of the scalp, removal of bone fragments, blood clot, and damaged brain tissue. The dura is closed without drainage. Patients with compound depressed fractures of the vault, with laceration of the brain, are often in surprisingly good condition and early operation may usually be undertaken. In civil life such fractures are often very inadequately treated, and extensive local infection of the brain is a common result.

*Injuries of the Spinal Cord.*—The results of treatment of penetrating spinal cord injuries in the First World War were very discouraging. Approximately 80 per cent of all patients with spinal cord injuries died within

the first few weeks. This was due in part to severe associated injuries, but there was also a high mortality from sepsis arising either from bed sores or urologic infection, or both. These results were not unexpected and, unfortunately, may not be greatly altered in any future conflict in which early transfer of patients to adequate hospital facilities is impracticable.

In all types of spinal injuries, proper handling of the patient is of greatest importance, in order to avoid damaging the cord or increasing the damage of an existing cord injury. Penetrating wounds of the spine may require operation for the purpose of disinfection or for the removal of the penetrating agent in partial lesions of the cord. The cord lesion may be physiologically complete from the concussional force of the penetrating missile even though the cord itself has not been hit. Many such cases recover function in a short time with little residual impairment, while in others the cord may be completely disintegrated by the concussion. Practically all that can be accomplished by operation in gunshot wounds of the spinal cord is the disinfection of the wound and removal of fragments of bone and foreign bodies which rarely cause compression.

At the U. S. A. Hospital, No. 11, Cape May, N. J., following the First World War, there was a small number of gunshot wounds of the spinal cord showing varying degrees of spinal cord impairment. In some of these cases the patients suffered intractable pain for which cordotomy was performed. The general condition of such patients was usually very bad, due to sepsis and long-continued suffering. This series was probably among the first group of cordotomies performed by Dr. Charles H. Frazier.

*Peripheral Nerve Injuries.*—The records of Base Hospitals, according to Davis and Pollock, show that 14 to 16 per cent of all wounds to the extremities in the American Expeditionary Force, caused injuries of the peripheral nerves; and it was estimated that wounds of the peripheral nerves constituted 4.5 per cent of all casualties. The larger number of these injuries were operated upon many months after the wounds were received and, although the final results of operation were not accurately ascertained in any considerable number of cases, analyses of end-results of small groups indicated that recovery of function was very incomplete. Débridement of deep wounds by inexperienced surgeons was evidently responsible in some cases for injury to the nerve which had escaped injury from the missile. Operations for nerve suture were delayed until after fibrosis had replaced normal muscle tissue, particularly in the intrinsic hand muscles. Much time was lost by relying on misleading signs of nerve regeneration, such as Tinel's sign, which, at the time, was regarded by some as possessing a degree of infallibility.

Before the primary operation for repair of deep wounds of the extremities, a neurologic examination should be made, in order to determine whether there is involvement of important nerves. The disinfection and débridement of such wounds, when nerve impairment is probable or evident, should be undertaken by those competent to expose, identify and suture a divided nerve at the time of the primary treatment of the wound. Early suture of a divided

## WOUNDS OF NERVOUS SYSTEM

peripheral nerve is desirable. Chemotherapy may be utilized to prevent or retard infection.

In patients with paralysis of a peripheral nerve, when the condition of the nerve was not ascertained at the time of the repair of the wound of the extremity, the type of nerve lesion should be investigated at open operation as soon as the local condition of the wound will permit. It is advisable to wait three months after healing of an infected wound before exploration and suture of the nerve, but it is important that infection be eradicated as early as possible so that later suture may not be delayed longer than absolutely necessary. If infection develops after primary suture of a nerve, it is often advisable to excise the suture line and resuture the nerve after the infection has been eradicated. Peripheral nerve lesions are often associated with injury to important blood vessels of the extremities, and this, undoubtedly, contributes to unsatisfactory end-results.

Physiotherapy and proper splinting are essential adjuncts to the successful treatment of peripheral nerve injuries. To obtain the best results, both should be started early and continued through the period of paralysis.

The attitude toward peripheral nerve lesions which have not been adequately dealt with at primary operation, should be one that encourages direct inspection of the nerve, so that an early decision may be arrived at as to the type of treatment the nerve itself requires. In other words, the attitude toward operation for the exposure of the nerve may well be radical, while the treatment of the exposed nerve lesion should incline to conservatism.

In the writer's experience at Cape May Hospital, which probably handled one of the largest groups of nerve injuries collected from the American Expeditionary Force, I was often impressed in delayed exploratory operation by finding complete division of nerves when repeated clinical examinations had appeared to justify the assumption that nerve function was recovering spontaneously. Such errors may be avoided by exploration of the paralyzed nerve when there is any doubt as to the type of nerve lesion present.

The exposure of peripheral nerves is a procedure of little difficulty to those familiar with anatomy of the extremities. Judgment may be critically tested in cases in which the nerve lesion is manifested by a neuroma in continuity. The conservative operation of neurolysis is often advisable in such circumstances. The protection of important branches of the injured nerve during the dissection, the excision of scar tissue from the nerve ends, accurate approximation of the nerve segments without tension or torsion, and careful hemostasis are essential details in a successful technic for nerve suture.

The use of autogenous transplants to bridge wide defects in peripheral nerves, has been, so far as I know, unsuccessful in every case. A novel method of repairing divided peripheral nerves has been suggested by Young and Medawar (*Lancet*, August, 1940). By their technic the divided nerve ends are held in approximation by a cuff of concentrated liquid plasma. The originators of the method, which, thus far, appears to be experimental,

claim that regeneration following this technic is superior in every respect to that of direct suture. The procedure, obviously, has decided limitations.

The facial nerve is sometimes paralyzed by gunshot wounds of the mastoid region. Facial paralysis resulting from such wounds usually requires anastomosis with another motor cranial nerve. The hypoglossal is preferred for this anastomosis. Traumatic lesions of other cranial nerves do not require surgical treatment.

Much was expected from the study of the large collection of peripheral nerve injuries resulting from the First World War. These nerve injuries were received in a space of a few months and were segregated in special hospitals with special staffs interested in the treatment of such injuries. The hospitals in which the patients were treated were well equipped surgically and provided with elaborate departments of physiotherapy and electrotherapy. Unfortunately, in the study of this large collection of nerve injuries no standardized criteria of recovery were formulated; and after the patients were discharged from the hospital there were no well directed efforts to determine the results of treatment. An unparalleled opportunity for definite information relative to nerve repair and nerve regeneration was, therefore, lost.

Under the most favorable conditions, regeneration of sutured peripheral nerves leaves much to be desired. The misdirection of fibers from the central stump cannot be prevented, although this may be minimized by accurate approximation of the nerve segments, without torsion. The defects of regeneration, shown by the straying of fibers from the central stump, greatly interfere with the results of suture of such important nerves as the ulnar and median.

Further research is needed on nerve transplantation, particularly in view of its almost universal failure in peripheral nerves, and the good results claimed for transplantation in facial nerve defects. It is also important to have further information on the relative effects of early and delayed suture in the final recovery of function, and after what length of time can no further benefit be expected from surgical treatment of divided nerves. The technic of nerve repair, the treatment of neuroma in continuity, the effects of neurolysis—all present problems which are by no means settled and are worthy of further study.

It is absolutely essential that standardized criteria of partial or complete recovery be formulated, if actual knowledge is to replace mere impression as to the regeneration of injured peripheral nerves. These criteria should be applied in determining the end-results of treatment of every peripheral nerve.

**DISCUSSION.—DR. JOHN S. MCEWAN** (Orlando, Fla.): I had a large hospital in France during the World War before the Americans went over, and I wish that we had had you specialists there at that time. We had to do surgery from the top of the head to the bottom of the feet. If Doctor Blair had been there to see the plastic work by the French, he would have been amazed. They really did some very remarkable plastic surgery on the face.

Far be it from me to discuss nerve surgery. I suppose we had many hun-

## WOUNDS OF NERVOUS SYSTEM

dreds of nerve suturings, but I have never seen them since operating, so the results we obtained are not known. In a large percentage of cases, these injuries were due to compound fractures, with loss of bone and nerve. After these cases came from the front and the wounds healed, bone was grafted and then followed suture of the nerves.

This reminds me of a true story of a Colonel in the army. In this case, the Colonel could not find the proximal end of the nerve in the arm, and he worked on it for hours, and still could not find it. Finally, he picked up a piece of fascia and started to suture it to the distal end of the nerve. A young doctor from Savannah said to him, "Colonel, that is not nerve; that is a piece of fascia." The Colonel replied, "When I say it is nerve, it is nerve"—and continued to suture it.

It was the dirty clothing in these gunshot wounds that gave us our worst infections. We picked out pieces of shirts and clothing that had been worn for weeks. It was not the shrapnel that caused the most serious infections, it was the contaminated clothing.

We found that the brain operations should be undertaken early, and I believe the best results we had were in those cases operated upon within the first ten days.

Speaking of chemotherapy, three weeks ago we had a lot of Negro orange pickers, who had been riding in a truck that was wrecked. Twelve of them were brought to the hospital. Among this number were three with fractures of the skull, two of them compound, with depressed fragments. They were full of dirt, sand, grass, and cockleburs, and one had brain tissue extruding through the wound. We operated upon these two compound fractures, raising the fragments, and then dusted sulfanilamide all over and in the wound, sutured them without drainage, and got a primary union in both cases.

## ABDOMINAL INJURIES\*

### PREVENTIVE AND PROPHYLACTIC ASPECTS

AMBROSE H. STORCK, M.D.

NEW ORLEANS, LA.

FROM THE DEPARTMENT OF SURGERY, SCHOOL OF MEDICINE, TULANE UNIVERSITY, NEW ORLEANS, LA.

THE DESTRUCTIVE CHARACTER of abdominal injuries incurred in the various theaters of modern warfare, as well as the increased difficulties of collection, transportation, and treatment of abdominal casualty cases have, to a great extent, counteracted the advances in methods for treating these war injuries. The multiplicity and anatomic destructiveness of most of the present wounds is incompatible with life, and even the injuries which are not inevitably fatal are usually so serious that survival of the patient is dependent upon the employment of every appropriate aid, both nonoperative and operative.

The situation which exists, in respect to abdominal injuries, in the present war was revealed in the discussions which followed the presentation of a paper by Kenneth M. Walker<sup>1</sup> concerning the protection of the soldier in warfare, before the Section of Surgery of the Royal Society of Medicine of England on June 26, 1940. This paper was discussed by prominent English surgeons, who presented data based on their own war experience or gained from others. Colonel A. E. Porritt<sup>2</sup> said that before the English forces left France in the present war, there were over 2,000 cases in Base Hospitals, and that he did not believe that there were among them a dozen chest or abdominal wounds, thus providing ample confirmatory evidence of the high mortality in such cases. While agreeing with Colonel Max Page<sup>3</sup> as to the enormous number of wounds which were due to missiles of low velocity, he commented on the marked relative increase in through-and-through wounds from machine and "Tommy" guns, seen in the latter weeks of the campaign in France. At the same meeting, Zachary Cope<sup>4</sup> read a note from a Major Underwood,<sup>5</sup> who stated that he was of the opinion that quite a number of the wounds seen during the present war were due to small, low velocity or medium velocity projectiles (Fig. 1). Major Underwood had remarked on the size of the fragments as compared with those in the last war. The feasibility of protecting soldiers from, at least, low velocity projectiles was generally agreed upon, and opinion was almost unanimously in favor of some sort of body armor. The discussion concerned not only protection of the abdomen and chest, but included consideration of protective appliances for other parts of the body. The need for protection of the abdomen was particularly emphasized. At this meeting, the following resolutions were carried unanimously:

"(1) That this representative meeting of the Royal Society of Medicine,

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## ABDOMINAL INJURIES

after a full discussion of the question, is emphatically, of the opinion that the physical protection of the members of the fighting force can and should be improved by a closer collaboration between the medical profession and the appropriate technical experts of the Admiralty, War Office, and Air Ministry;

"(2) That this meeting of the Royal Society of Medicine resolve that the Council of the Society be asked to consider the formation of a special committee to this end, according to by-law 21; furthermore, as the matter is, in the opinion



FIG. 1.—Fragment of English high explosive shell from present European war.

of this meeting, one of extreme urgency and importance, it is hoped that the President may use his emergency powers and approach the Government with the offer of the Society's cooperation at the earliest possible date."

The present review of abdominal injuries will be limited to a general consideration of the methods, especially certain newer ones, for reducing the incidence of, and ameliorating the serious nature of abdominal injuries. Specific injuries, and details of treatment such as were included in a paper<sup>6</sup> presented before this Society last year, will be omitted.

The preventive and prophylactic problems which will be discussed are as follows:

(A) Preventive Problems

- (1) Reduction of total number of war wounds.
- (2) Reduction of extent of individual wounds.
- (3) Reduction of multiplicity of wounds in an individual.

(B) Prophylactic Problems

- (1) Prevention and prophylaxis of infection.
  - (a) Peritonitis
  - (b) Wound infection
- (2) Prophylaxis and early treatment of shock.
- (3) Adequate treatment of hemorrhage.

The methods whereby these problems may be at least partially solved are as follows:

**PREVENTIVE MEASURES.**—Although complete prevention of abdominal injuries is obviously impossible, there are means of substantially reducing the total number as well as the extent and multiplicity of these wounds.

*Education of Armed Forces and Civilians.*—Education concerning precautionary measures to be taken both by armed forces and civilians will materially reduce the incidence of abdominal injuries. Many of the injuries which can be prevented by this means are caused by bricks, pieces of cement or concrete, timber and structural steel hurled from buildings, streets, or roads which have been bombed.

*Airplane and Artillery Raid Shelters.*—The need for adequate shelters for protection against air-raids and artillery fire is fully recognized and requires no detailed discussion. The difficulty encountered in persuading people to avail themselves of these facilities is well-known to everyone from accounts in the daily newspapers. The full benefits which may be achieved by this sort of protection are dependent upon adequate public education.

*Armor for Vehicles and Equipment.*—The inclusion of protective shields as parts of field guns has long been customary. Motorized equipment, such as motorcycles and trucks, in which troops are transported are likely to be objects of attack, either by air or from the ground and, insofar as it is possible, armor protection should be included in the construction of this type of equipment. In the instance of motorcycles, windbreaks for the protection of the head, chest, abdomen, and legs can be incorporated without difficulty. Armor-lined airplane cockpits have been found effective in saving pilots and gunners, not only from injuries by projectiles but from burns.

*Body Armor.*—Most attempts to gain acceptance of body armor as standard equipment have met with passive or active resistance by authorities, who either considered the matter not worth discussing or who advanced what they considered irrefutable objections to its use. It is interesting to know that for some time following the acceptance of the steel helmet, now considered indispensable, this innovation met with much adverse criticism.

Various arguments which have been advanced for and against the use of body armor are as follows:

Against:

- (1) Adds too much weight to equipment.
- (2) Decreases freedom of motion.
- (3) Deforms bullets.
- (4) Ineffectual against high velocity direct axial hits.
- (5) Unacceptable to soldier.
- (6) Insufficiently tried.

For:

- (1) Abdominal wound almost invariably fatal.
- (2) Weight requirements met by new light metals.

## ABDOMINAL INJURIES

- (3) Motorized equipment has increased feasibility.
- (4) Arrests most low velocity projectiles.
- (5) Deflects many high velocity projectiles.
- (6) Most injuries due to oblique hits by small, low velocity projectiles.
- (7) Improves morale.
- (8) Increases efficiency.
- (9) Conserves man-power.
- (10) Humane.
- (11) Releases equipment and men.
- (12) Reduces replacement-requirements.
- (13) Relieves congestion on roads.
- (14) Used by invaders during recent conquest of Belgium.



FIG. 2.—Body armor for protection of chest and abdomen  
(after Kenneth M. Walker<sup>1</sup>).

Most present-day war casualties are caused by missiles of low velocity, roundly, those traveling at a rate of less than 1,000 feet per second, to which the lightest type of helmet and armor is proof. Extremely convincing evidence in favor of body armor is the fact cited by Walker,<sup>1</sup> that it was used by the invaders during the recent conquest of Belgium. A type of armor which has been given consideration for use by the United States army is shown in Figure 2.

If it were known to an enemy force that their opponents were only protected

by armor covering the chest and abdomen, all accurate firing would be directed at the unprotected areas. It is, therefore, suggested that a jerkin-type of armor might be designed in which the rear half would be made in detachable sections, which could be shifted to pockets in the front or back of trouser legs or sleeves to afford protection to thighs, legs, and upper extremities as circumstances indicate. Because the weight carried by troops is so important, as much as

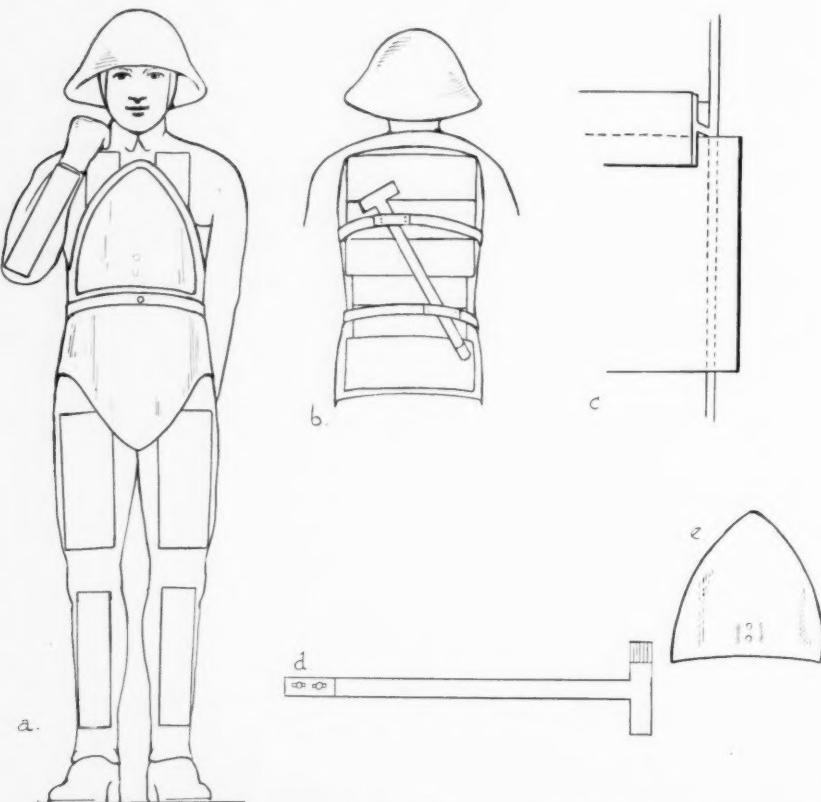


FIG. 3.—Suggested type of body armor. (a) Front view. (b) Posterior element, with removable sections which might be slipped into "pockets" for protection of upper and lower extremities. (c) Construction detail of posterior element. (d) Shovel handle, to be used as water canteen. (e) Removable portion of breast plate which might be used as entrenching shovel blade.

possible of the essential equipment, *i.e.*, shovel, canteen, *etc.*, should be incorporated into the body armor; for instance, the shovel blade could constitute part of the chest armor, and a further reduction in the total weight of equipment could be accomplished by using a hollow metal shovel handle as a canteen. Figure 3 is a diagrammatic representation of a body armor arrangement here-with suggested as adaptable for affording a wide range of protection without undue increase in weight.

The materials which have most often been suggested or tested in respect to their suitability for body armor include: Chain mail; wire mesh or net; sheet metal, notably manganese steel, chromium steel, silicon nickel steel; aluminum

## ABDOMINAL INJURIES

alloys; rubber; laminated metal and rubber; woven silk; cork; compressed canvas; leather; asbestos; paper; cotton; rayon; bakelite and other plastics; miscellaneous fibers, hemp, sisal, hair, flax, kopak, balata.

The increasingly fatal nature of war wounds, the development of acceptably light yet resistant metals, and the feasibility of equipping troops with body

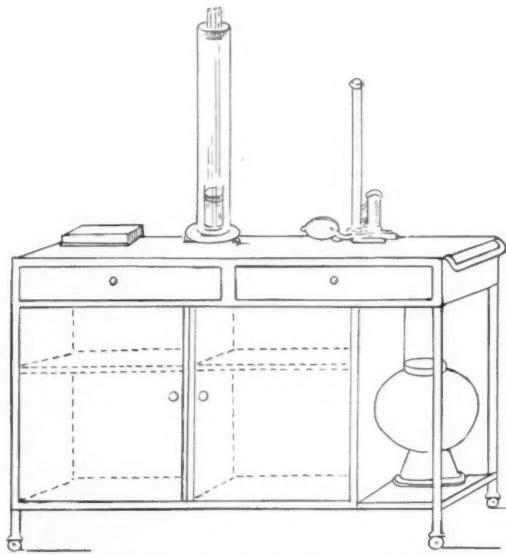


FIG. 4.—Portable "shock cart" which includes apparatus and supplies for studying and treating shock and hemorrhage. Indicated on top are pieces of apparatus for falling-drop estimations, blood cell counts, and blood pressure determinations. Centrifuge at base on right is for mean corpuscular volume studies. The drawers contain syringes, sterile linen, and direct transfusion equipment. The compartments below the drawers contain preserved plasma, serum, or whole blood; saline and glucose solutions; tubing and drip meters; and drugs.

armor when transportation is motorized, is leading to adoption, in some form or other, of this form of protection.

**PROPHYLACTIC MEASURES.**—Prophylactic measures will be considered in two categories: (1) Those which may be instituted in anticipation of possible injury; and (2) those which have to do with the care of patients after abdominal injury has been sustained.

*Before Injury Is Incurred.*—Precautions which may be taken, and methods of preparation which will be considered for possible employment in anticipation of abdominal injuries, include evacuation of the large bowel and abstinence from food shortly before anticipated injury, and methods for killing or replacing pathogenic bacteria normally present in the intestine.

The advantage of having the large bowel and the stomach as empty as is possible at the time of an abdominal injury is obvious, and civilians as well as troops should be advised to evacuate the bowel and avoid eating at times when they are likely to be wounded in the abdomen.

The possibility of killing bacteria in the intestinal tract by the oral adminis-

tration of sulfanilylguanidine<sup>7</sup> immediately brings to mind the possibility of preventing or reducing the severity of peritonitis by administering this drug to civilians or members of the armed forces when it is known beforehand that they are to be exposed to the danger of abdominal injury. The practicability of such preparation would depend upon the toxic effects and impairment of efficiency caused by the administration of the drug.

It has been shown,<sup>8, 9</sup> that it is possible to practically eliminate the pathogenic organisms normally present in the intestine by feeding cultures of Lactobacilli either alone or in conjunction with a diet which facilitates the transformation of the intestinal flora. It is conceivable that elimination of pathogenic organisms from the intestinal tract by this method might, at least, considerably reduce the severity of peritonitis following penetrating abdominal wounds. Since this method of ridding the intestine of pathogenic bacteria not only does not impair nutrition, but causes no toxic effects, it would be, if equally efficacious, superior to the sulfanilylguanidine method of intestinal preparation. Experimental investigations, in pursuance of this idea, are in progress in the Department of Surgery at Tulane.

*After Injury Is Incurred.*—After an abdominal injury has been incurred, rapid transportation of the patient to an hospital unit is of vital importance. Insofar as rapid evacuation to an hospital unit minimizes shock and hemorrhage, transportation facilities must be considered in the category of prophylactic measures. The disruption of facilities for evacuating casualty cases is exaggerated by the speed and wide range of modern warfare, and is a prime factor in increasing the mortality associated with abdominal wounds. The destruction by airplane bombing of railroads or highways already congested by refugees, is likely to bring ground level transportation equipment to a standstill. In order to avert the disastrous results of delay in abdominal casualties, adequate provisions must be made for transfer by airplane whenever possible. As in the instance of motor ambulances, ambulance train coaches, and airplane ambulances should be heated, and ambulance trains should be equipped for the treatment of shock by modern methods en route to hospitals out of the combat zone. Under some circumstances, older types of equipment such as horse-drawn ambulances might, even now, afford a more rapid or gentle means of evacuating the wounded over open or rough country when blocked roads stop the movement of motorized ambulances.

Motorized mobile hospital units which afford operating facilities must be placed as near the front as is compatible with efficiency, and enough of this sort of equipment must be provided to adequately care for the urgent demands which are likely to be made on it for the care of large numbers of casualties.

Infection involving the peritoneal cavity and its contents as well as the abdominal wall wound remains a serious problem in those cases who survive long enough to develop these complications. Fortunately, however, the demonstrated beneficial effects of the sulfonamide drugs, administered through various routes, is encouraging and this form of therapy should be promptly instituted. The prophylactic value of transfusions of blood or plasma, and the administra-

tion of cevitamic acid is well established in the treatment of infections of either the peritoneum or abdominal wall.

Advances in knowledge concerning the treatment of peritonitis gained in civil practice, including the proper supplying of fluid and mineral requirements, the use of the Miller-Abbott tube, the administration of large doses of morphine, etc., find direct application in the prophylaxis or early treatment of peritoneal infection complicating abdominal injuries.

The benefits accruing from the early application of established principles in the treatment of wound infection, *i.e.*, débridement, wound drainage, and immobilization, may in some instances be increased through the prompt administration of appropriate antisera.

In the instance of infections due to the micro-aerophilic hemolytic streptococcus, the value of the zinc peroxide paste, advocated by Meleney,<sup>10</sup> seems to be adequately established not only in the treatment of already established areas of infection, but as a means of preventing extension of the inflammatory process.

The use of nonabsorbable suture material, in order to avert or reduce the incidence of serious wound infection and wound disruption, must be included in the category of preventive measures applicable in the management of wounds due to abdominal injury. Adequate drainage of the abdominal wall wound may prevent the development of an intramural abscess, which, by rupturing into the peritoneal cavity, can cause death.

Prophylactic roentgenotherapy, for the purpose of reducing the incidence of gas bacillus infection, has been advocated and employed in many instances, particularly in wounds of the extremities. Although this therapeutic measure might be of some prophylactic value in war wounds of the abdomen, definite information in this respect is not available.

Reports concerning the value of miscellaneous antiseptics for the prophylaxis of wound infection must be subjected to critical estimation.

For the prevention as well as the treatment of shock, the benefits afforded through the early institution of means to provide adequate rest and maintain body heat should not be lost sight of due to enthusiasm over newer additional methods. Under the trying conditions of war, when other forms of treatment are oftentimes not possible, almost entire reliance must frequently be placed in simple methods, as securing rest and preserving body heat. On the other hand, when time and facilities allow, determination of specific gravity changes in the blood by means of the falling-drop method<sup>11</sup> makes possible the early detection of shock and prompts the institution of therapy before the irreversible deleterious effects of prolonged shock have occurred. The importance of the early administration of blood plasma in conjunction with adrenal cortical hormone and hypertonic sodium chloride solution, as advocated by Scudder,<sup>12</sup> and others, is now generally accepted and constitutes a great advance in the prophylaxis and treatment of shock. The administration of 100 per cent oxygen has also been shown to be of value both in averting and treating shock. Apparatus such as the Boothby-Lovelace-Bulbulian<sup>13,14,15</sup> mask, and the intranasal catheter method have increased the practicability of this type of therapy.

tration of sulfanilylguanidine<sup>7</sup> immediately brings to mind the possibility of preventing or reducing the severity of peritonitis by administering this drug to civilians or members of the armed forces when it is known beforehand that they are to be exposed to the danger of abdominal injury. The practicability of such preparation would depend upon the toxic effects and impairment of efficiency caused by the administration of the drug.

It has been shown,<sup>8, 9</sup> that it is possible to practically eliminate the pathogenic organisms normally present in the intestine by feeding cultures of Lactobacilli either alone or in conjunction with a diet which facilitates the transformation of the intestinal flora. It is conceivable that elimination of pathogenic organisms from the intestinal tract by this method might, at least, considerably reduce the severity of peritonitis following penetrating abdominal wounds. Since this method of ridding the intestine of pathogenic bacteria not only does not impair nutrition, but causes no toxic effects, it would be, if equally efficacious, superior to the sulfanilylguanidine method of intestinal preparation. Experimental investigations, in pursuance of this idea, are in progress in the Department of Surgery at Tulane.

*After Injury Is Incurred.*—After an abdominal injury has been incurred, rapid transportation of the patient to an hospital unit is of vital importance. Insofar as rapid evacuation to an hospital unit minimizes shock and hemorrhage, transportation facilities must be considered in the category of prophylactic measures. The disruption of facilities for evacuating casualty cases is exaggerated by the speed and wide range of modern warfare, and is a prime factor in increasing the mortality associated with abdominal wounds. The destruction by airplane bombing of railroads or highways already congested by refugees, is likely to bring ground level transportation equipment to a standstill. In order to avert the disastrous results of delay in abdominal casualties, adequate provisions must be made for transfer by airplane whenever possible. As in the instance of motor ambulances, ambulance train coaches, and airplane ambulances should be heated, and ambulance trains should be equipped for the treatment of shock by modern methods en route to hospitals out of the combat zone. Under some circumstances, older types of equipment such as horse-drawn ambulances might, even now, afford a more rapid or gentle means of evacuating the wounded over open or rough country when blocked roads stop the movement of motorized ambulances.

Motorized mobile hospital units which afford operating facilities must be placed as near the front as is compatible with efficiency, and enough of this sort of equipment must be provided to adequately care for the urgent demands which are likely to be made on it for the care of large numbers of casualties.

Infection involving the peritoneal cavity and its contents as well as the abdominal wall wound remains a serious problem in those cases who survive long enough to develop these complications. Fortunately, however, the demonstrated beneficial effects of the sulfonamide drugs, administered through various routes, is encouraging and this form of therapy should be promptly instituted. The prophylactic value of transfusions of blood or plasma, and the administra-

## ABDOMINAL INJURIES

tion of cevitamic acid is well established in the treatment of infections of either the peritoneum or abdominal wall.

Advances in knowledge concerning the treatment of peritonitis gained in civil practice, including the proper supplying of fluid and mineral requirements, the use of the Miller-Abbott tube, the administration of large doses of morphine, etc., find direct application in the prophylaxis or early treatment of peritoneal infection complicating abdominal injuries.

The benefits accruing from the early application of established principles in the treatment of wound infection, *i.e.*, débridement, wound drainage, and immobilization, may in some instances be increased through the prompt administration of appropriate antisera.

In the instance of infections due to the micro-aerophilic hemolytic streptococcus, the value of the zinc peroxide paste, advocated by Meleney,<sup>10</sup> seems to be adequately established not only in the treatment of already established areas of infection, but as a means of preventing extension of the inflammatory process.

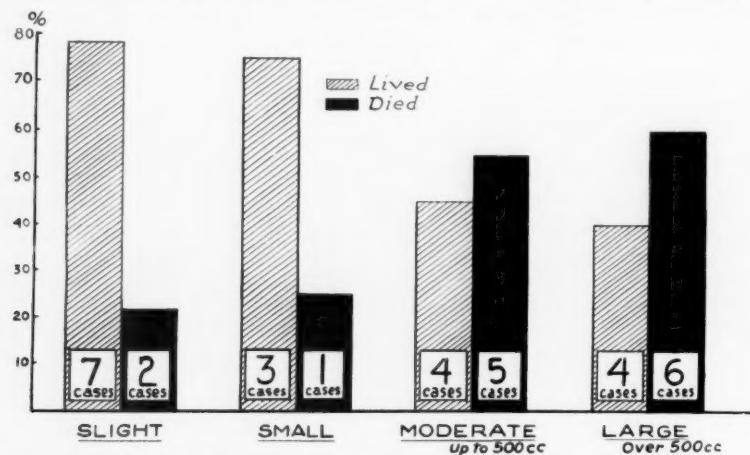
The use of nonabsorbable suture material, in order to avert or reduce the incidence of serious wound infection and wound disruption, must be included in the category of preventive measures applicable in the management of wounds due to abdominal injury. Adequate drainage of the abdominal wall wound may prevent the development of an intramural abscess, which, by rupturing into the peritoneal cavity, can cause death.

Prophylactic roentgenotherapy, for the purpose of reducing the incidence of gas bacillus infection, has been advocated and employed in many instances, particularly in wounds of the extremities. Although this therapeutic measure might be of some prophylactic value in war wounds of the abdomen, definite information in this respect is not available.

Reports concerning the value of miscellaneous antiseptics for the prophylaxis of wound infection must be subjected to critical estimation.

For the prevention as well as the treatment of shock, the benefits afforded through the early institution of means to provide adequate rest and maintain body heat should not be lost sight of due to enthusiasm over newer additional methods. Under the trying conditions of war, when other forms of treatment are oftentimes not possible, almost entire reliance must frequently be placed in simple methods, as securing rest and preserving body heat. On the other hand, when time and facilities allow, determination of specific gravity changes in the blood by means of the falling-drop method<sup>11</sup> makes possible the early detection of shock and prompts the institution of therapy before the irreversible deleterious effects of prolonged shock have occurred. The importance of the early administration of blood plasma in conjunction with adrenal cortical hormone and hypertonic sodium chloride solution, as advocated by Scudder,<sup>12</sup> and others, is now generally accepted and constitutes a great advance in the prophylaxis and treatment of shock. The administration of 100 per cent oxygen has also been shown to be of value both in averting and treating shock. Apparatus such as the Boothby-Lovelace-Bulbulian<sup>13,14,15</sup> mask, and the intranasal catheter method have increased the practicability of this type of therapy.

The direct relationship between the amount of hemorrhage and the mortality in penetrating wounds of the abdomen, graphically shown in Chart 1, is based on observations in a series of personal cases, and is in accordance with the findings of others. Since hemorrhage is such an important factor as a cause of death following abdominal injuries, the value of early administration of adequate amounts of whole blood or plasma is apparent. The remarkable developments



### Mortality in Relation to Degree of Hemorrhage

CHART 1.—Showing relationship between amount of hemorrhage and mortality in the author's personal series of penetrating wounds of the abdomen.

which have occurred within the last several years in respect to the transfusion of whole blood and especially the demonstration of the benefits derived from the administration of fresh or preserved blood or of various blood elements, have greatly advanced the treatment of hemorrhage, and shock due to hemorrhage. There have been numerous critical reports concerned with the relative merits of pooled plasma, preserved whole blood, dried serum, and fresh whole blood. For the treatment of shock unassociated with considerable hemorrhage, pooled plasma seems to be superior to other types of blood transfusion. When shock is associated with hemorrhage, pooled plasma may again be employed to advantage, especially if fresh whole blood is not available. If the full benefits which may result from the transfusion of whole blood or various blood elements are to be attained, it is necessary that these substances be given promptly and in sufficiently large amounts. The delayed administration of even large transfusions is ineffectual in reversing the deleterious effects of prolonged shock. The production by Smith, and his coworkers<sup>16</sup> of a potent preparation of thrombin, capable of causing practically instantaneous clotting when applied to a bleeding surface, suggests the present possibility of promptly arresting bleeding from torn liver surfaces by means of this substance.

#### SUMMARY

The destructive and complicated character of abdominal wounds incurred in modern warfare, and the difficulty of quickly transporting these casualty cases, is responsible for an appallingly high mortality rate, and is forcing the

## ABDOMINAL INJURIES

consideration of abdominal injuries from the preventive and prophylactic standpoints. Fortunately, there are methods whereby not only the present number of immediately fatal injuries can be reduced, but there are also means whereby more of the less seriously injured abdominal casualty cases may be saved.

Preventive measures, for the reduction of the total number of injuries, include education in respect to precautions that should be taken by armed forces and civilians at times when the danger of incurring abdominal injuries can be reasonably anticipated, the provision of adequate shelters for protection in case of airplane or artillery raids, armor protection for vehicles and equipment, and adoption of some type of body armor.

Of the prophylactic measures for the reduction of the serious consequences and complications of abdominal injuries, some may be instituted beforehand, while others are applicable after injury is incurred. Measures which may be employed, before injury is incurred, are concerned with reducing the incidence or severity of peritonitis resulting from perforation of the hollow alimentary tract viscera. Measures which may be employed, after injury is incurred, are concerned with avoidance of delays in evacuation due to inadequate transportation facilities, the use of motorized mobile hospital units, the application of advanced knowledge concerning the treatment of peritonitis and wound infection, and the supplementary employment of methods for the study and treatment of shock and hemorrhage.

### REFERENCES

- <sup>1</sup> Walker, Kenneth M.: The Protection of the Soldier in Warfare. *Proc. Roy. Soc. Med.*, **33**, 607, 1940.
- <sup>2</sup> Porritt, Col. A. E.: Discussion of Walker.<sup>1</sup>
- <sup>3</sup> Page, Col. Max: Discussion of Walker.<sup>1</sup>
- <sup>4</sup> Cope, V. Zachary: Discussion of Walker.<sup>1</sup>
- <sup>5</sup> Underwood, Major: Cited by Zachary Cope in discussion of Walker.<sup>1</sup>
- <sup>6</sup> Storck, Ambrose H.: Penetrating Wounds of the Abdomen; an Analysis of 46 Personal Cases. *ANNALS OF SURGERY*, **111**, 775, 1940.
- <sup>7</sup> Marshall, E. K., Jr., *et al.*: Sulfanilylguanidine (Sulfanilamide Derivative); Chemotherapeutic Agent for Infections. *Bull. Johns Hopkins Hosp.*, **67**, 163, 1940.
- <sup>8</sup> Bass, C. C.: Personal communication.
- <sup>9</sup> Rettger, Leo F., and Cheplin, H. A.: A Treatise on the Transformation of the Intestinal Flora. Yale Univ. Press, 1921.
- <sup>10</sup> Meleney, Frank L.: Treatment of Traumatic Wounds with Zinc Peroxide. New York State Jour. Med., **39**, 2188, 1939.
- <sup>11</sup> Barbour, H. G., and Hamilton, W. F.: Blood Specific Gravity; Its Significance and a New Method for Its Determination. *Am. Jour. Physiol.*, **69**, 654, 1924.
- <sup>12</sup> Scudder, John: Shock: Blood Studies as a Guide to Therapy. Philadelphia, Lippincott, 1940.
- <sup>13</sup> Boothby, W. M.: Oxygen Administration; Value of High Concentration of Oxygen for Therapy. *Proc. Staff Meet., Mayo Clinic*, **13**, 641, 1938.
- <sup>14</sup> Lovelace, W. R., II: Oxygen for Therapy and Aviation; Apparatus for the Administration of Oxygen or Oxygen and Helium by Inhalation. *Proc. Staff Meet., Mayo Clinic*, **13**, 646, 1938.
- <sup>15</sup> Bulbulian, A. H.: Design and Construction of Masks for the Oxygen Inhalation Apparatus. *Proc. Staff Meet., Mayo Clinic*, **13**, 654, 1938.
- <sup>16</sup> Smith, H. P.: Blood Clotting and the Control of Hemorrhage. *Tr. Kansas City Acad. Med.*, 1937-1939, pp. 243-264.

## AIDS IN AVOIDING SERIOUS COMPLICATIONS IN THYROIDECTOMY\*

FRANK H. LAHEY, M.D.

BOSTON, MASS.

FROM THE DEPARTMENT OF SURGERY, THE LAHEY CLINIC, BOSTON, MASS.

To WRITE under such a title as the above, at least two assumptions are necessary: (1) That all of the serious complications, here discussed, have occurred several times to the one who suggests methods to avoid them; and (2) that the methods suggested to avoid them have been employed not once or twice but in a sufficiently large series of cases that one can, with the faith established by this experience, confidently recommend their employment. A third postulate could reasonably be required of a writer on this subject, namely, that definite evidence in the way of mortality rates in a large series of cases be adduced to demonstrate that real results had been accomplished by the employment of these measures.

In a very large series of thyroid operations, practically every possible complication which could arise has occurred, not once but, of necessity, a great many times. With increasing experience, with increasing facilities, mechanical and laboratory, and with an increasing number of minds in the group applied to these problems, the methods here discussed have been developed and so applied that, in the entire series of 19,700 thyroid operations, the mortality rate is only 0.76 per cent.

One of the most serious and constant complications in thyroid surgery is that of thyroid reaction, sometimes called thyroid crisis or thyroid storm. When these reactions follow surgical procedures they are most often due to not having appreciated, preoperatively, the intensity of the hyperthyroidism, the seriousness of the risk and the probability of the degree of postoperative reaction. There is one definite aid in this condition which is often overlooked and which will do a great deal to avoid this mistake. If, when the patient is seen at his first visit to the hospital, clinic or physician's office, a note is recorded on his history as to whether or not, because of the intensity of his intoxication, more than a one-stage procedure will be necessary, it will avoid, in many instances, the possibility of the mistake of undertaking too much surgery upon a patient who is too bad a risk. Unless one records this impression when the patient is first seen, he may well be put to bed, put upon a high carbohydrate diet, on Lugol's solution, often with intravenous glucose solution, and again seen by the surgeon who is to operate upon him a day or two before the operation is undertaken with the purpose of settling at that time as to whether or not graded procedures are to be employed. When patients are seen after seven or eight days' rest in bed

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## COMPLICATIONS IN THYROIDECTOMY

and preparation, and the decision made then, the interpretation of the hazards of the procedure is often not a justifiable one. What one needs to remember is that immediately after the operation the patient will be as bad as he was when first seen at his worst, or in even a greater degree of thyroid reaction. If there be on the patient's record the warning that the operation should be performed in two or three stages, and, under the anesthetic while the operation is being performed, there be evidences of considerable reaction, these two points will lead one to limit the procedure to a less extensive one than a complete subtotal thyroidectomy.

We have repeatedly stressed what we have learned from a large clinical experience, that the three outstanding factors which indicate surgical hazards in operation upon a patient with a toxic thyroid are—age, weight loss, and the length of time they have had the disease. Older people stand thyroid toxicity and postoperative thyroid reaction distinctly less well than do younger people. Weight loss, when occurring without dietary measures, is a direct indication of the prolonged effect of an elevated metabolism, and one must realize that not only does the weight loss occur, but prolonged diminution in the protective elements in the liver likewise occurs as the result of this positive metabolic imbalance. The length of time which patients have had hyperthyroidism is likewise an indication of a possible serious post-operative reaction because, as with weight loss, long-standing hyperthyroidism means long-standing positive metabolic imbalance with undesirable effects, particularly upon liver function, over this period of time.

There is nothing which can mislead one as to the possible degree of thyroid risk and possible postoperative reaction more than metabolic readings. This is particularly true because they are reported in percentage figures, and so, by those who are not dealing with thyroid disease daily, can be interpreted in degrees of risk in relation to the height of the metabolism.

High metabolic rates, if truly basal, undoubtedly are indicative of severe degrees of thyroid intoxication, but one can by no means assume that patients with relatively low metabolic readings will not at times have even more serious postoperative thyroid reactions than those with high basal rates. It is for this reason that it is extremely important to say that the height of the metabolism is by no means a trustworthy indication of the possible degree of the postoperative thyroid reaction.

As may be seen in Chart 1, we have found that the administration of glucose solution on the morning of the operative day, providing, as it does, something extra for the patient to burn during the hours of his temporarily stimulated metabolism, has distinctly decreased the degree of postoperative thyroid reaction in the patients with severe degrees of thyroid toxicity.

It seems unnecessary, to-day, to urge the relationship of multiple-stage operative procedures to low mortality rates in thyroid surgery. I would like to urgently stress the fact that states of thyroid toxicity vary in different individual practices, that they vary in different parts of the country and that no

plan of 100 per cent employment of one-stage operative procedures in thyroid surgery, as has been advocated by some, be accepted without very definite reservations by those practicing thyroid surgery in other parts of the country from where these series are reported.

Not only is it necessary, preoperatively, to arrive at some conclusions as to the degree of operative risk in relation to the possible postoperative thyroid reaction, but one often finds that decisions to limit the extent of the operative procedure must be made during the actual performance of the operation. It is of great importance, therefore, in patients upon whom there is any doubt as to the seriousness of their state of thyroid toxicity, that but one-half of the thyroid be uncovered, that only one hemithyroidectomy be completed, and the situation then reviewed as to the patient's immediate state and the decision made as to whether or not operation upon the other side should be undertaken at this time. An aid in determining not to proceed beyond a first-stage hemithyroidectomy in this uncertain situation is the amount of oxygen which the patient is consuming. A normal individual will consume approximately 250 cc. of oxygen per minute, while a patient with hyperthyroidism, during the operation, may consume up to 800 cc. per minute. When, therefore, patients are consuming a large amount of oxygen, this is a possible suggestion that no more than a first-stage subtotal hemithyroidectomy should be undertaken.

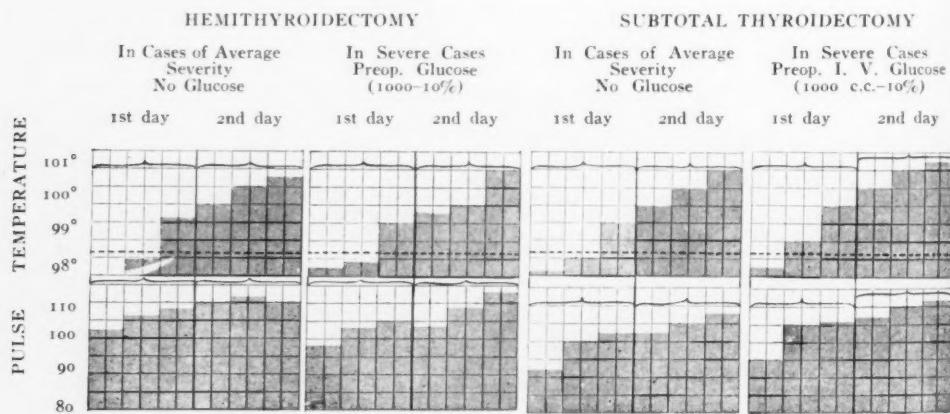


CHART 1.—Postoperative pulse and temperature responses in hyperthyroidism in patients with and without glucose solution on the morning of operation. Note in the severe cases that these patients who had had glucose on the day of operation had no more, or even less, reaction than the less severe cases in which glucose solution was not administered.

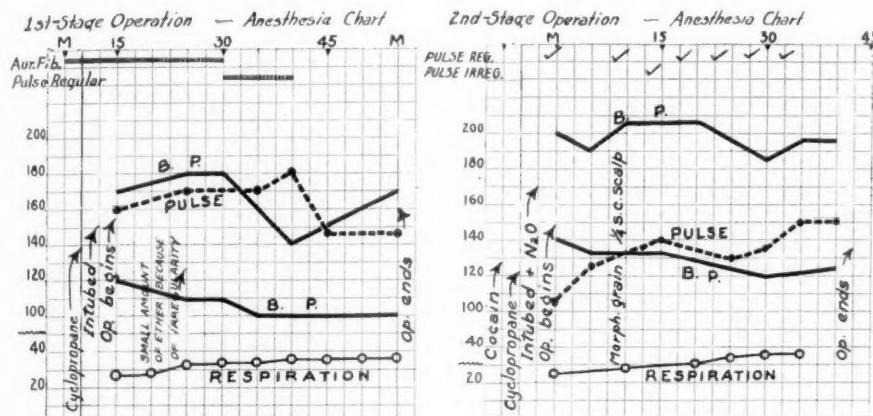
Pulse pressure is probably one of the best indications of the immediate degree of thyroid toxicity, and when, during the operation, the pulse pressure is gradually widening, this, likewise, is an indication of increasing thyroid toxicity and for a termination of the procedure by means of a first-stage subtotal hemithyroidectomy (Chart 2).

Another indication of possible postoperative thyroid reaction is a rising pulse rate and an increased demand for the amount of anesthetic. Those

## COMPLICATIONS IN THYROIDECTOMY

patients whose pulses are progressively rising and who are requiring greater and greater depths of anesthetic mixture to keep them anesthetized are, likewise, candidates for first-stage hemithyroidectomy.

Still another indication of the intensity of thyroid toxicity is the degree



## OPERATIVE FACTORS SUGGESTING MULTIPLE-STAGE OPERATION

1. Slight effect from premedication
2. High O<sub>2</sub> consumption
3. Widening pulse pressure
4. Persistent rapid or irregular pulse
5. Vasomotor instability

CHART 2.—Operative factors suggesting advisability of multiple-stage operation: (1) Slight effect from premedication; (2) high oxygen consumption; (3) widening pulse pressure; (4) persistent rapid or irregular pulse; and (5) vasomotor instability.

with which they react to the preoperative narcosis. Those patients who come to the operating room in active excitation, in spite of the preoperative administration of an adequate amount of narcotics, should be looked upon with suspicion as to possible postoperative reaction. The reverse, however, is not to be depended upon.

Perhaps nothing in the past has played a greater part in the production of undesirable complications in thyroidectomy than anesthesia. For practical purposes there are two types of anesthesia that may be employed for thyroid surgery: (1) Regional anesthesia which may consist of either local infiltration or cervical plexus block; and (2) inhalation anesthesia consisting of ether or one of the gaseous anesthetic agents such as nitrous oxide, ethylene or cyclopropane or various combinations of these. Mention is not made of avertin since it is generally combined with inhalation anesthesia and may more properly be considered as a preanesthetic drug.

We have always felt that local anesthesia interferes with the adequacy of thyroid exposure, and the delicacy of the anatomic dissection. In addition to that, we believe that it is a psychic burden upon the patient unless an amount of preliminary drugging is employed which practically amounts to a form of anesthesia. We have, likewise, always felt that undiluted ether is undesirable because of the struggling that is so often related to its induc-

tion and the nausea which so frequently follows its employment. The seriousness of prolonged postoperative vomiting for a patient with hyperthyroidism cannot be overemphasized. The serious disturbance of blood chemistry and the interference with the intake of fluid and fuel as a result of prolonged vomiting certainly tend to increase postoperative thyroid reaction, and have undoubtedly caused the balance to be swayed not infrequently on the side of a fatality.

Nitrous oxide anesthesia has some advantages in thyroid surgery. It is entirely nonexplosive and, as a rule, produces relatively little postoperative nausea and vomiting. It does, however, have a very great disadvantage (and this is of great importance to patients with hyperthyroidism) in the fact that nitrous oxide anesthesia alone is always associated with some degree of anoxemia. Since nitrous oxide is such a weak anesthetic drug, in order to maintain adequate anesthesia it is frequently necessary to carry patients with oxygen concentrations as low as 9 to 10 per cent.

Ethylene anesthesia offers some advantages over nitrous oxide. Like nitrous oxide, it is associated with relatively few instances of prolonged postoperative vomiting but, in contradistinction to nitrous oxide, it is quite explosive in almost all concentrations in which it is employed for anesthesia. Since it is a stronger anesthetic drug than nitrous oxide, higher concentrations of oxygen may be employed with it (approximately 15 per cent). We feel that this is still a rather low concentration of oxygen for patients with hyperthyroidism who are known to have increased metabolic rates.

Cyclopropane offers many advantages over either of the two above-mentioned gases. It is, as a rule, associated with very few disturbances in physiology. This gas is a very powerful anesthetic agent and may be administered in concentrations so low as to allow for concentrations of oxygen as high as 85 or 90 per cent. It does, however, have the distinct disadvantage of being explosive when mixed with oxygen, in practically all of the concentrations in which it is used for anesthesia.

Because of the fact that, for the above reasons, we have so often advocated the use of cyclopropane anesthesia for thyroid surgery we would like to utter a warning concerning its employment. As a result of further and more extensive experience with this agent, we should like to urge that it not be employed in an undiluted form in patients with thyroid toxicity or in patients with heart disease. It has been known for a long time that high concentrations of cyclopropane might produce cardiac irregularity, particularly in patients with thyroid toxicity; and is even more prone to do so in those patients who definitely have some degree of cardiac damage associated with their hyperthyroidism. We feel certain that fatalities on the operating table due to sudden cessation of heart action caused by ventricular fibrillation, associated with cyclopropane anesthesia, have occurred in our experience. As a result of these experiences we do not now employ this agent in an undiluted form for anesthesia in patients suffering from hyper-

## COMPLICATIONS IN THYROIDECTOMY

thyroidism or heart disease. It is extremely important, I believe, to stress this point because of the popularity of this anesthetic agent.

Whenever a patient with serious hyperthyroidism is operated upon, the margin of safety is undoubtedly at times quite narrow. It must be accepted, also, that, at times, in this operation even the most experienced thyroid surgeon will meet with technical operative difficulties. It must, likewise, be admitted that even the most experienced anesthetist will also meet with

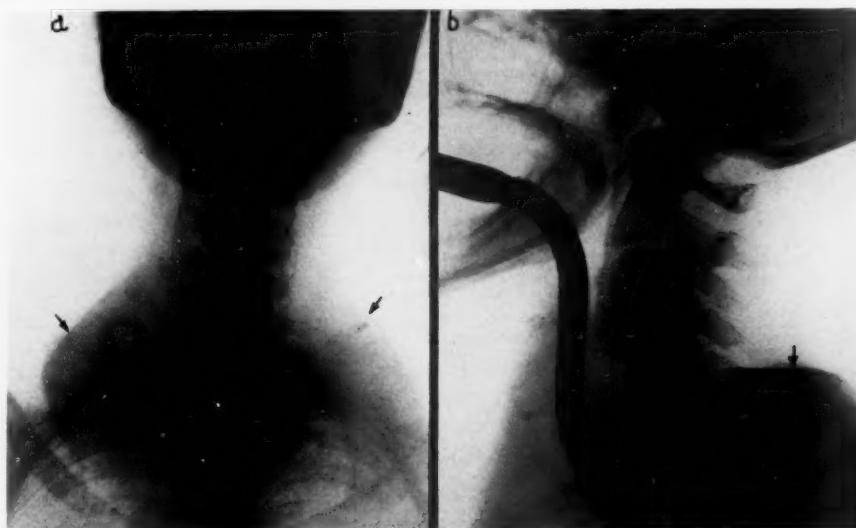


FIG. 1 (a) and (b).—These roentgenograms show the spiral-walled, flexible metal catheter introduced into the trachea. (a) Anteroposterior view; and (b) lateral view. Note in (a) the extent of the goiter and the deviation of the trachea. One can readily understand, in this type of large adenomatous goiter as well as in exophthalmic goiter, how manipulation to the trachea can be carried on with no interference with the airway.

anesthetic difficulties during thyroid operations. When these two difficulties, an interference with breathing producing anoxemia and technical difficulties, are combined during a thyroid operation, they can result in an operative fatality.

I will speak later about methods of avoiding technical operative difficulties. Anesthetic difficulties in the way of interference with breathing can absolutely be avoided by the introduction of a noncollapsible intratracheal catheter before the operation is undertaken. This requires but little time, and, in the hands of an anesthetist expert in its employment, can be accomplished with no difficulty whatever. It insures a complete airway at all times, complete quietness of the field, and the elimination of at least one of the serious possible complications of thyroidectomy (Fig. 1).

Many thyroid deaths are undoubtedly the result of technical operative complications. These result in prolongation of the operation, inadequate control of bleeding, interference with anatomic relations, and undue loss of blood. They result in injury to the parathyroid bodies, injuries to the nerves, and at times even in injury to the trachea. If two principles are

observed, there should almost never be serious technical operative difficulties in performing a thyroid operation: The first is adequate exposure—the pre-thyroid muscles cut, the skin flap dissected high, the venous blood supply,

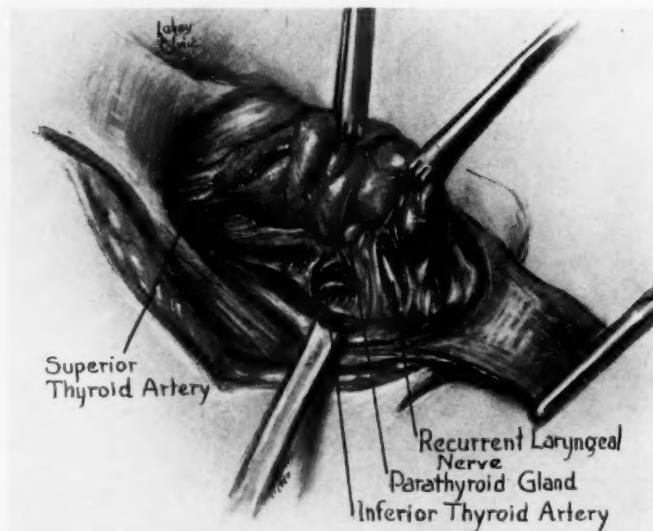


FIG. 2.—A drawing showing the thyroid lobe freed from the internal jugular vein; dislocated from its bed and held up so that it is suspended only by its attachment to the trachea. Note in it the recurrent laryngeal nerve, parathyroid gland, inferior and superior thyroid artery.



FIG. 3.—A photograph, taken at the operating table, to illustrate an actual picture of the method of mobilizing the gland and lifting it up out of its bed. Note in it the nerve marked (N), artery marked (A), and the superior thyroid artery marked with an arrow.

the superior, middle and inferior thyroid veins, detached from their point of entrance into the internal jugular vein; and the second, that the lobe of the thyroid is elevated from its bed and held up with double hooks (Figs. 2 and 3). With this exposure, and with the common carotid artery and

## COMPLICATIONS IN THYROIDECTOMY

internal jugular vein dissected back from the thyroid gland down to the scalenus anticus, and with the superior thyroid artery, inferior thyroid artery, recurrent laryngeal nerve and parathyroids visualized, technical difficulties are, for practical purposes, completely avoidable (Figs. 2 and 3).

Hemorrhage during a thyroidectomy should never be in any way beyond the surgeon's complete control. The main blood supply to the thyroid is the superior thyroid artery and the inferior thyroid artery, both of which, if adequate exposure and anatomic dissection be accomplished, are visualized and can be ligated with safety. It has frequently been asked of us whether or not the ligation of both the superior and the inferior thyroid blood supply, on both sides, might not bring about tetany. Although we do not do it routinely, we have repeatedly ligated both the superior and inferior thyroid arteries on both sides, never with the production of tetany. No thyroid operation of any type, except possibly removal of a simple discrete adenoma, should ever be undertaken without the entire anatomy of the thyroid gland, including its superior and inferior arteries so completely visualized that should any excessive bleeding occur they can be immediately ligated and thus bleeding be entirely controlled.

It is unnecessary to discuss nerve injuries since we have written so extensively on the subject of visualization of the recurrent laryngeal nerves. One does well to remember, however, two or three warnings regarding this structure. The recurrent laryngeal nerve occasionally does not recur, but as stated in my article\* on the subject, passes directly across from the vagus to enter directly beneath the inferior constrictor muscles. At times, this nerve descends a little further but not into the chest, and comes directly across from the vagus to hook under the inferior thyroid artery and then ascends to its position in the larynx. One must remember that the recurrent laryngeal nerve in its normal position not infrequently passes over the branches of the inferior thyroid artery or through the branches of the inferior thyroid artery, and if the lobe of the thyroid be mobilized from its bed and held upward as advised by us in these dissections it will be so pulled up that unless carefully demonstrated it can rather easily be injured (Fig. 4).

One of the most distressing complications of thyroid surgery is that of inadvertently making a hole in the trachea during the operation. Unless the correct procedure is undertaken, very properly, at this time, a serious outcome may result. If blood is sucked through the hole into the trachea, such an amount of coughing will result that the patient cannot be kept under the anesthetic; will struggle; come out of the anesthesia; become excited; suck in more blood, and eventually a fatality will result.

Should this complication arise there are two things to be done. A finger may immediately be placed over the opening into the trachea and held there until all bleeding is completely controlled and until the wound is absolutely

\* Lahey, F. H.: Routine Dissection and Demonstration of the Recurrent Laryngeal Nerve in Subtotal Thyroidectomy. *Surg., Gynec., and Obstet.*, **66**, 775-777, April, 1938.

dry, at which time the finger can be removed and silk sutures inserted to close the opening. If an expert in the anesthesia of thyroidectomy is giving the anesthetic, and is immediately informed of this emergency, he can so increase the gas pressure in the trachea that air will constantly blow out and no blood go in, so that black silk sutures can be inserted to close the opening, with no blood able to enter the trachea. I know of no complication which can be more immediately serious than this, nor do I know of one which requires more prompt or more correct management.

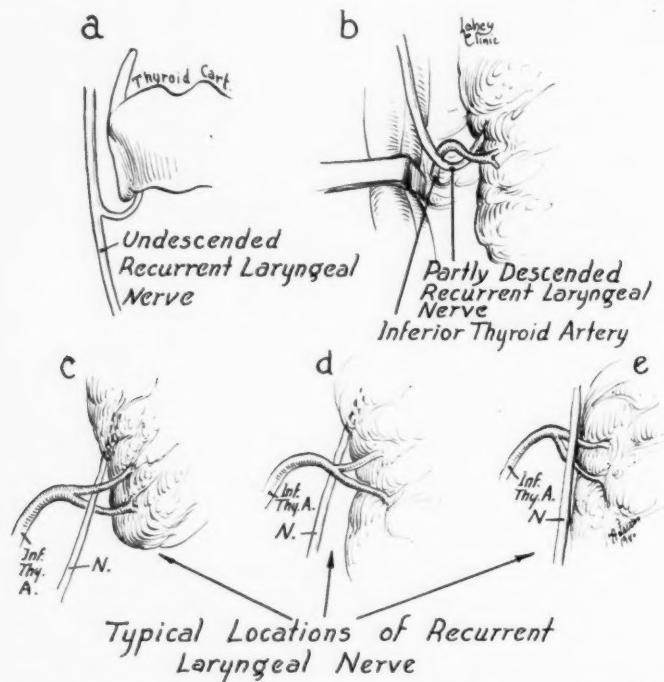


FIG. 4.—(a) Shows the unusual, but occasional, undescended inferior laryngeal nerve passing directly from the vagus to beneath the horn of the thyroid cartilage. (b) Partly descended nerve passing underneath the inferior thyroid artery but not descending into the chest and ascending to be inserted into the larynx. (c), (d) and (e) The three common locations of the recurrent laryngeal nerve in relation to the inferior thyroid artery.

Undoubtedly, many patients with thyroid disease are lost because of postoperative difficulties, among which is prolonged anoxemia. Everyone seems to hesitate or fear to perform postoperative tracheotomy in patients operated upon for thyroid disease. This is, in some measure, related to pride and, in some measure, to a fear of the production of pneumonia or, in deeper goiters, of mediastinitis. Most of these fears are groundless, and should there be any question whatever that a patient, postoperatively, is not receiving an adequate supply of oxygen, a tracheotomy should at once be performed. Those patients with a slight degree of cyanosis as a result of tracheal obstruction, who are permitted to go through the night suboxygenated and have a tracheotomy on the following morning, frequently continue to sink into un-

## COMPLICATIONS IN THYROIDECTOMY

consciousness and coma, and die. Had these patients had a tracheotomy earlier, many of them, undoubtedly, would have been saved. When there is any question that patients with postoperative tracheal obstruction are not getting an adequate supply of oxygen, a temporary tracheotomy should be promptly established.

It is important that if these tracheotomies are to be but temporary and the tube removed within a few days, they be made at a proper level, and that is well down on the tracheal rings, below the level of the cricoid cartilage. At the level of the cricoid cartilage the trachea is the narrowest, and while this is the easiest point at which to perform a tracheotomy, it is the point, because it is the narrowest point of the trachea, at which stricture following removal of the tube is most likely to occur.

One of the most important points, in avoiding serious postoperative complications in thyroidectomy, is that in every patient upon whom a thyroidectomy is performed the trachea should be completely bared at the time of the operation. This is of value for two reasons: We have insisted that only by complete removal of the isthmus is it possible to remove adequate amounts of thyroid tissue; but just as important is the fact that by the removal of the isthmus the tracheal rings are so bared that should a tracheotomy become necessary postoperatively, valuable time will not be wasted removing the isthmus during the emergency, and an immediate tracheotomy can be performed quickly and easily (Figs. 5 and 6).

Postoperative hemorrhages after thyroidectomy are largely avoidable at the time of operation. Mass ligatures and gland suture in thyroid surgery have, in my opinion, no place in the control of thyroid bleeding. Vessels should be tied individually and accurately. One is apt to forget that the danger of a postoperative hemorrhage in patients, particularly with hyperthyroidism, is not so much the hemorrhage itself but rather related to the fact that they occur immediately after the operation or on the following day, at a time when the patient is in some considerable degree of postoperative thyroid reaction. If it becomes necessary to take this patient to the operating room or to give him an anesthetic or perform an operative procedure upon him for the control of hemorrhage during this stage of postoperative thyroid reaction, the already existing thyroid reaction may well be so intensified that it can throw the balance in the direction of a fatality, which was avoidable. When postoperative thyroid hemorrhages occur with any frequency, one cannot avoid the conclusion that they could have been avoided had more care been exercised in exposure and ligature of vessels.

One of the most distressing types of postoperative thyroid hemorrhage is when the ligature of the superior thyroid artery slips. The artery, being the first branch of the external carotid, bleeds profusely, and, producing, as it does, clots of blood high up under the muscle flap, is difficult to find and control. Attention to one point in ligature of this artery will prevent many of these hemorrhages. Never ligate the superior thyroid artery up under a skin flap with inadequate elevation of the skin flap and exposure of the

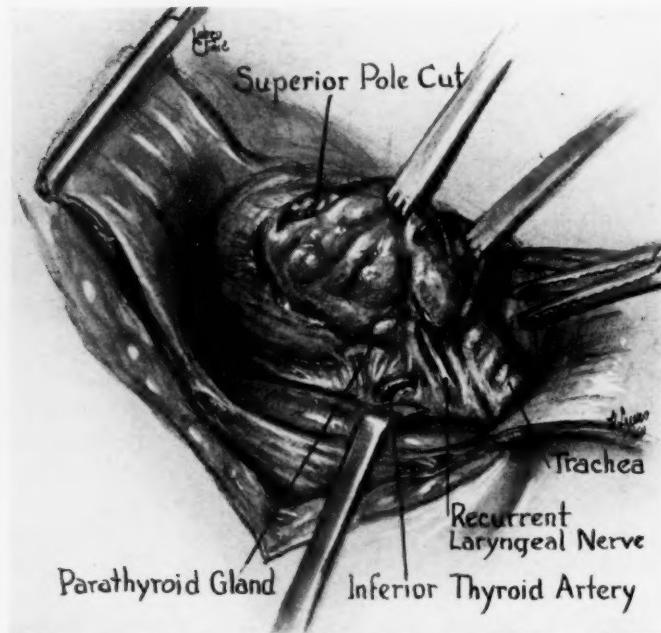


FIG. 5.—A drawing illustrating the detachment of the mobilized thyroid gland by severing the superior thyroid vessels, and by detaching the isthmus from the trachea so that the thyroid hangs only by the attachment of the body of the thyroid to the lateral wall of the trachea. By this mobilization and exposure the anatomic structures are visualized and the entire extent of the thyroid can be estimated so that radical and adequate percentages can be removed.

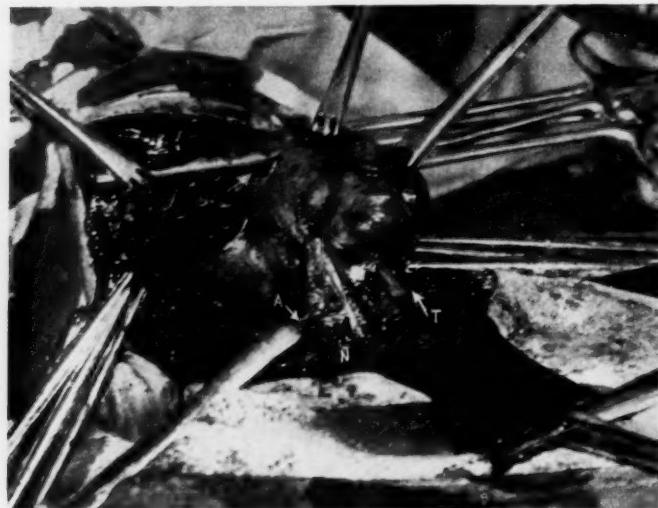


FIG. 6.—Actual photograph at operation. Note in this illustration, and in Figure 5, the bared trachea, the nerve, the artery, the severed superior pole, and the parathyroid gland.

## COMPLICATIONS IN THYROIDECTOMY

vessel itself. So visualize the superior thyroid artery that it can be ligated as a trunk, well off the thyroid gland itself (Fig. 7). If the ligature is passed around the upper pole of the thyroid, as is so often the case, without this exposure it can include the tip of thyroid tissue into which the superior

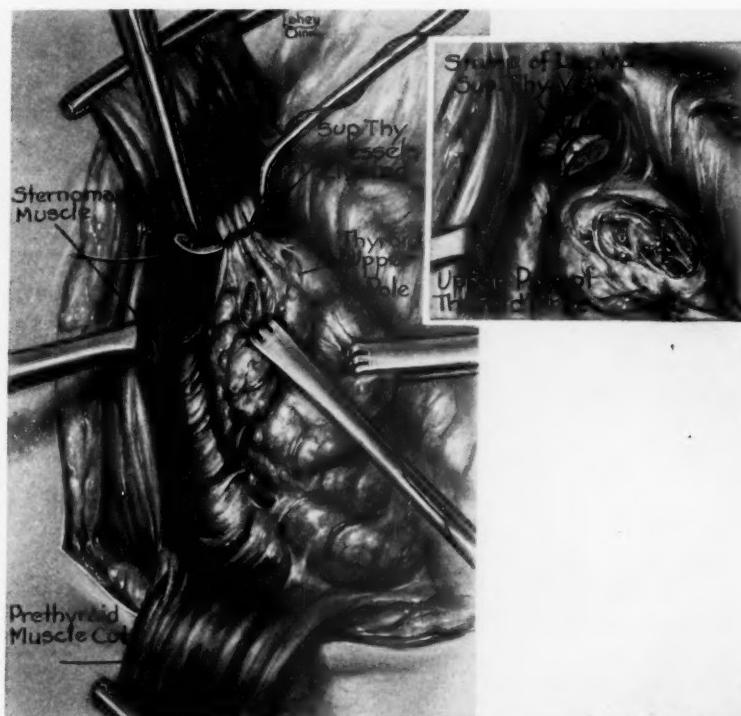


FIG. 7.—This illustrates the complete visualization of the superior thyroid artery and vein, and their ligature entirely off the thyroid gland. In the insert the remaining stump distal to the ligature is vessel and not thyroid tissue.

thyroid artery passes, which will interfere with adequate shutting down of the vessel. This will often temporarily occlude the vessel, only to permit the tie to be coughed off with vomiting or with movements after the patient leaves the operating room and is returned to bed. Failure to observe this step has undoubtedly resulted in many serious postoperative hemorrhages from the superior thyroid artery. The same warning, likewise, applies to adequate exposure and ligature under direct vision when the inferior thyroid artery is tied.

There are two types of thyroid hemorrhage, one of which can bring about a very prompt and immediate fatality. The other is of but little importance. One, the latter, is that hemorrhage, occurring beneath the skin flap which bulges the skin flap out, is painful, and immediately obvious, but as a rule does not interfere with breathing because it makes but little pressure on the trachea. This can be cared for readily by elevation of the skin flap and control of the venous bleeding point. When, however, the bleeding is

from either a superior or inferior thyroid artery, beneath the prethyroid muscles, the accumulation of blood unable to escape from beneath the muscles exerts such pressure upon the trachea that complete tracheal obstruction can occur, resulting in prompt and immediate suffocation.

We have had four or five such experiences where patients' lives have been dramatically saved by having the neck wounds promptly pulled open, with no antiseptic precautions, by anyone at hand; immediate removal of the clot; and prompt and complete restoration of breathing. This is a real emergency in which immediate separation of the muscles and bailing out of the clot, with the introduction of a pack until the bleeding can be controlled, must be instituted at once. Failure to do this, undoubtedly, will and has resulted in many fatalities.

After this large experience with thyroid surgery, if I were asked to state what, in my opinion, exclusive of a fatality, was the most undesirable operative complication in a patient operated on for thyroid disease, I would unhesitatingly say *tetany*. While the administration of calcium chloride, parathormone and dihydrotachysterol (A.T. 10) now controls tetany quite well, there are cases which do not respond satisfactorily to the employment of these measures. Their cost is not inconsiderable, and the symptoms of tetany, when they occur, are not only distressing but incapacitating. The apprehension associated with their possible occurrence is very disturbing to any individual in whom this complication has occurred. When we are able to report that in this entire series of thyroid operations there have been but ten cases of established tetany and that tetany has not occurred in the last 4,000 thyroid operations, it will be obvious that the complication is avoidable.

If certain procedures which we have definitely established are followed, the occurrence of tetany following thyroid operations should be almost completely eliminated. The factors controlling the preservation of the parathyroid glands are related to the employment of a few simple rules. The location of the parathyroid glands is not infrequently atypical, but in the majority of cases they can be demonstrated if one obtains an adequate exposure, with the prethyroid muscles cut. Why there should be such sentimental discussions as to whether or not the prethyroid muscles should be cut, I have never been able to understand. We have cut literally thousands of prethyroid muscles, we have observed the end-results over a long period of time, and if they are cut high, well up under the skin flap and above the point where the innervation enters the gland, there will be no disfigurement and little, if any, added discomfort. In our hands, at least, it is not possible to obtain as adequate exposures of the region of the recurrent laryngeal nerves and the parathyroid glands with the muscles uncut as can be obtained with them cut. The advantages of not cutting the muscle are, in my opinion, trivial compared with the benefits and safety resulting from the more adequate exposure which can be obtained with the muscles cut across.

The most important thing in preserving parathyroid glands is that the

## COMPLICATIONS IN THYROIDECTOMY

thyroid gland, as shown in Figure 2, be completely detached from its venous attachment to the internal jugular; picked up with double hooks, inserted in its outer border; pulled out of its bed and so lifted that it hangs by its attachments to the trachea, thus exposing the posterior aspect of the gland where, with a dry field and a good light, the region of the parathyroids may be clearly demonstrated, adequately inspected, and these structures dependably preserved. It will be impossible to be certain of preserving parathyroid glands unless thyroid operative fields are absolutely dry. In the presence of pools of blood and oozing vessels, parathyroids will go unrecognized and, of necessity, occasionally be unnecessarily removed. Too many thyroid operations are undertaken with the assumption that thyroid surgery must be performed in the presence of a large amount of venous and arterial bleeding. In addition to the above suggestions, the ordinary amount of illumination of an operative field will be inadequate for satisfactory demonstration of anatomic structures as minute as are those involved in thyroid surgery—parathyroids and recurrent laryngeal nerves. In further addition to this, there will be times at which, even with these requirements fulfilled, uncertainty will still exist as to the identity of certain gland-like structures suspected of being parathyroids. Under such conditions the Berens-Beebe loupe magnifying glasses, as previously suggested by me, will usually demonstrate whether or not the uncertain structures are parathyroids.

Another undesirable complication of thyroid surgery, particularly surgery for hyperthyroidism, is the removal of too much or too little thyroid tissue. I have written on this subject, giving indications for radical removal and for less radical removal in relation to how well a gland involutes under iodine, and the relation of blood iodine to the necessity of radical removals of thyroid tissue. As has been stated in the prevention of tetany, no plan which deals with percentage removal of the thyroid gland and percentage preservation of the thyroid remnant can hope to be effectual unless similar warnings as those stated in connection with the prevention of tetany are recognized. Most cases of recurrent hyperthyroidism are the result of attempting subtotal thyroidectomy without adequate exposure and adequate mobilization of the thyroid gland, and without adequate demonstration of the anatomic structures, such as the recurrent laryngeal nerve and parathyroid glands. When one knows where the recurrent laryngeal nerves and parathyroids are and can see them all the time, radical removals of thyroid tissue can be undertaken. When this is not true, the tendency will be to leave too thick remnants of thyroid tissue behind to protect them from injury. In Figure 2 will be seen the operative maneuver by which the thyroid gland, with the prethyroid muscles cut, is detached from its venous connection with the internal jugular vein, mobilized from its bed between the great vessels, the trachea and the esophagus, and lifted up, with its recurrent laryngeal nerve so demonstrated that it can be proven to be in its normal position, and so demonstrated that one can, with safety, ligate the vascular attachment to the inferior pole and the isthmus of the gland, and that structure turned up from

the trachea. The superior thyroid artery and vein can be ligated, and the upper pole so turned down that the thyroid gland is attached only at its body to the side of the trachea and at the point where the inferior thyroid artery enters the gland and the parathyroids are attached to the gland. In addition to this, the isthmus can be so detached from the trachea and the opposite lobe that only that body portion of the thyroid which is attached to the lateral wall of the trachea is left behind. In our experience, when this method of detaching the thyroid gland from the isthmus and from its upper

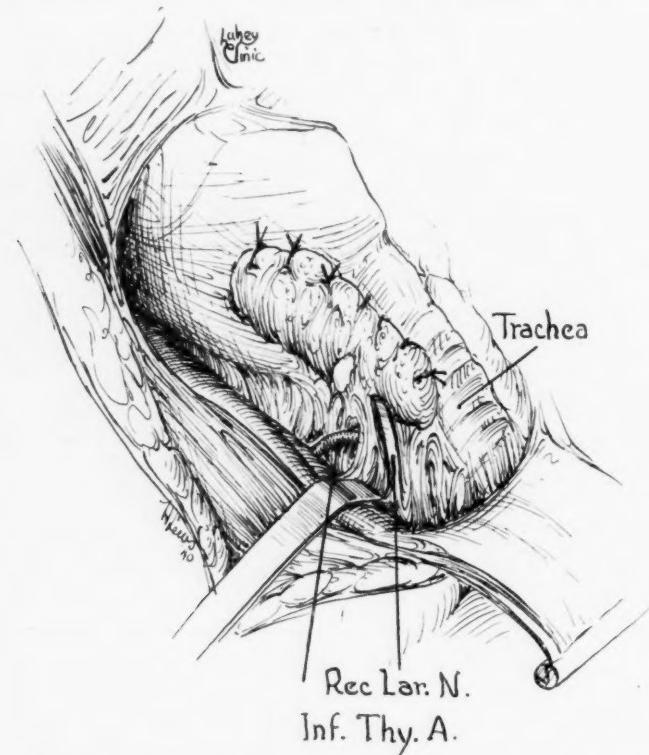


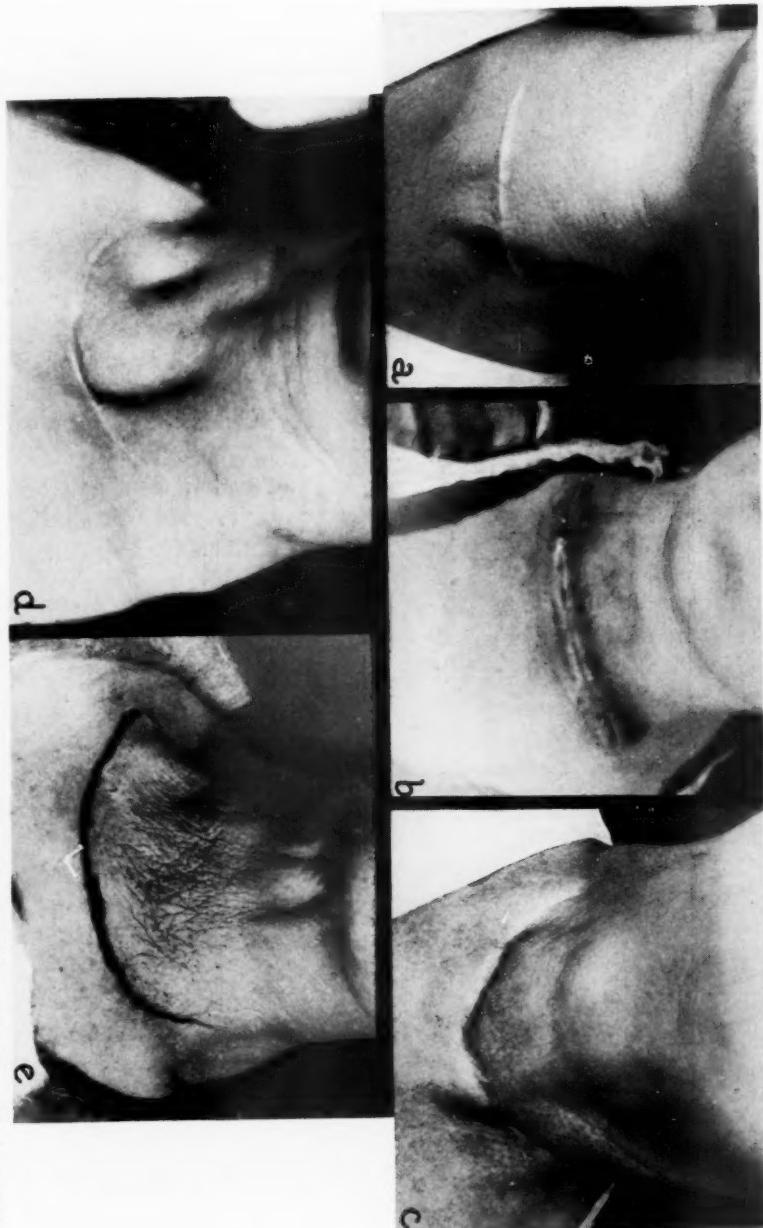
FIG. 8.—A drawing illustrating the method of suturing the remnant of thyroid against the trachea to control oozing, by which it is possible to almost entirely eliminate drainage in subtotal thyroidectomy for exophthalmic goiter.

and lower attachments to the trachea is employed, adequate removal of thyroid tissue with preservation of the recurrent laryngeal nerves and the parathyroids can be accomplished. This has been, in our experience, the safest and most reliable method of removing a sufficient amount of thyroid tissues without damage to other structures (Fig. 6).

The method of suturing the thyroid remnants against the trachea, shown in Figure 8, has also eliminated one of the unnecessary and undesirable post-operative complications, and that is drainage. Almost no patient operated upon for hyperthyroidism during the last several years, in our experience, has required postoperative drainage.

## COMPLICATIONS IN THYROIDECTOMY

FIG. 9.—(a) Showing an incision resulting in a scar which is placed so high that it cannot be successfully concealed. (b) An incision has been made too straight and with inadequate curve, so that it does not fall into the folds between the neck and the chest, where the neck joins the chest. In addition to this is illustrated in its central portion an undesirable complication of keloid formation, difficult to avoid in certain skins. (c) An improperly placed incision over a very large and prominent goiter. The scar has slipped down over the front of the chest to a position where it cannot be concealed. Had compensatory elevation of the incision been made, it would have descended to its proper level in the groove between the neck and the chest.



It is interesting to observe that one may have operated upon a woman for an hyperthyroidism so severe that she is practically incapacitated, may accomplish slowing of the pulse to normal, elimination of all undesirable nervous symptoms, and restoration of weight to a normal level, yet when this patient is seen with this striking change at the end of a year she will not infrequently fail to remark upon her physical improvement but state her pleasure in the postoperative results in the terms of the beauty of the scar. If the scar be unsatisfactory, she may utterly fail to express appreciation of the physical improvement, and complain bitterly of the appearance of the scar. It is for this reason that postoperative thyroid scars are of such importance, situated as they are in a region constantly exposed, and since nine out of ten thyroid operations, in our experience, are performed upon women, with these facts in mind, it is obvious that an unsightly thyroid scar is an important postoperative thyroid complication.

The location of the scar is of extreme importance. Many unsightly scars are placed too high, where they are constantly visible and cannot be concealed by beads (Fig. 9 a). The mistake of placing them too low is made much less often than placing them too high. Many unsightly thyroid scars are unbalanced, one side being higher than the other. Another bad feature of thyroid scars is that they are not infrequently made too straight rather than curved, which prevents them from disappearing largely in the fold between the neck and its attachments to the chest (Fig. 9 b). Another unsightly thyroid scar, as these cases come to us, is the horse-shoe type, in which the lateral limbs run too far up over the side of the neck (Fig. 9 c). It is important that thyroid scars be symmetrically curved as shown in Figure 9 d, so that they fit and, at least partially disappear in the fold at the junction of the neck and chest.

A common mistake which is made in thyroid incisions, as we have repeatedly stressed in discussing this subject, is that with prominently projecting goiters an incision is placed at the proper level at the time of operation, but when this tumor has been removed, because of the slipping of the loose and prominent skin of the neck, it descends to an unsightly position on the front of the chest where it cannot be concealed. In the same way, when the prominence of the neck from a one-sided goiter is unilateral, due to the fact that on one side there will be skin slippage greater than on the other, a scar which at the time of operation is well placed, will tilt on one side in an unsightly manner (Fig. 9 e). These are but a few of the undesirable complications in relation to scars which occur following thyroid surgery, most of which can be avoided by attention to a few simple details.

#### SUMMARY

An attempt has been made to discuss and illustrate some of the serious, undesirable and largely avoidable complications associated with partial thyroidectomy. The measures developed in a large experience with the operation are likewise discussed, described and illustrated.

## COMPLICATIONS IN THYROIDECTOMY

DISCUSSION.—DR. GEORGE M. CURTIS (Columbus, Ohio): At my first appearance before this Association, may I express my appreciation of the privilege of becoming a Fellow. It has been a pleasure to hear these two papers concerning thyroid disease. The unquestioned experience of the one and the insight of the other speaker have resulted in a profitable clinical review.

One question, however, arises, and I would like to make one suggestion. The question concerns the mechanism of the beneficial effect obtained after ligating the superior thyroid arteries. We have employed this procedure, as have so many, and undoubtedly benefit at times comes from it. On the other hand, after studying the collateral arterial supply to the thyroid gland, it became evident that the blood supply is but little affected by the usual ligature. Moreover, the thyroid gland receives its principal blood supply from the inferior thyroid arteries rather than from the superior. Too, the collateral interconnection between the superior thyroid arteries and the arteries of the larynx, pharynx, trachea and esophagus is most extensive. It would, consequently, appear that the beneficial effect is not particularly due to a diminution of the greatly increased blood supply. Rather, it would seem more reasonable to regard the good results as due to ligature of the accompanying nerves. It would be interesting to hear further discussion concerning this matter.

Perhaps the most severe immediate postoperative complication is the thyroid "crisis" or "storm." Prevention of this is, thus, the more important, and is mainly brought about by adequate preoperative management. Since prevention has become so significant, every effort should be made to accomplish it.

Patients with hyperthyroidism do not hold iodine. Careful balance studies reveal that they progressively deplete themselves of iodine. Moreover, when iodine is administered, it is first stored, but eventually hyperthyroid patients lose the amount which is stored, and even more, after the administration is stopped. In similar manner, it is not so generally known that patients with hyperthyroidism, likewise, deplete themselves of calcium. Careful studies of this matter were originally made by Aub and his associates. More recently we have confirmed these studies and have also added the beneficial effect of thyroidectomy.

We find patients with advanced exophthalmic goiter greatly depleted of calcium owing to a greatly increased negative calcium balance, which may be even greater than that of patients with hyperparathyroidism. Because of these findings, some time ago we began to give our patients calcium preoperatively, as well as iodine.

It has been shown that vitamin D increases the permeability of the intestine to calcium. Therefore, we used high vitamin D along with the calcium. We found, subsequent to instituting this principle of replacement therapy, that our postoperative reactions were less severe. Moreover, we have not had one real "storm" since calcium replacement was also added to the usual preoperative therapy.

On the other hand, all-around careful preoperative preparation, as has been outlined, is paramount. It is difficult to conclude that administration of calcium and vitamin D is any single outstanding factor, nevertheless the rationale of this replacement is evident and we consequently give it. Calcium may be readily given as milk. Calcium lactate is best given in solution. The mechanism whereby calcium replacement is of particular value is not yet clear. An adequate subtotal thyroidectomy, however, abruptly halts the depletion of calcium storage.

DR. ROBERT S. DINSMORE (Cleveland, Ohio): Last year I had the pleasure of dedicating an article on this same subject in Doctor Lahey's birthday book. There are two minor points which might be mentioned in the preparation of these cases, which I think are danger signals. These are the presence of a recent delirium, or a pulse curve which will not come down. After all, the question of technic is more or less an individual problem. A satisfactory technic is one which, in a properly prepared patient, can be done with a minimum of anesthesia; in a reasonable length of time; with the removal of the proper amount of thyroid tissue; protection of the recurrent laryngeal nerve and parathyroids; a resultant satisfactory scar; and, above all, the cure of the patient.

The question of exposure of the nerve is again an individual problem. Personally I do not do it. Doctor Lahey wants to see where it is, and I want to see where it is not; in other words, he wants to see it every day and I never want to see it. In this connection, there is one thing which might be mentioned; I have had men ask me to show them the nerve, as Doctor Lahey does. As you have seen from his illustration, he only exposes it at its vital points, but many surgeons have the impression that Doctor Lahey exposes it in its entirety, which is not correct.

There is one distressing complication which I wish to mention, that is, postoperative psychosis. A differentiation should always be made between true toxic delirium of hyperthyroidism and a major psychosis. You are dealing with two diseases if a psychosis develops; in other words, you have a psychosis and hyperthyroidism, and if one of your patients develops this complication, you can tell the family that the psychosis is a separate disease and has nothing to do with the hyperthyroidism. In every such instance we have had, a psychiatrist has been able to elicit a previous history of psychosis in that individual. Sometimes you are blamed because these patients may have to go to a sanitarium. The last such patient I had has been in a sanitarium for a long time with dementia praecox, and peculiarly enough, two of her neighbors came in with simple goiters and asked that they be taken out before they too went crazy.

To return for a moment to the question of nerve injuries—sometimes nerves are injured in most unexpected ways. I was always under the impression that it was almost impossible to have a recurrent laryngeal nerve injury when an intrathoracic goiter was extruding itself from the thorax. However, I once had a very delightful old doctor with an intrathoracic goiter, and he was particularly anxious about his voice, as he sang bass in a choir. After the upper pole was freed, he literally coughed the right lobe out of his chest, and, at this time, he had a voice change which proved to be a recurrent laryngeal nerve injury which has never recovered. This was an instance, in the absence of instrumentation, in which I actually saw the change take place.

DR. ROBERT W. BARTLETT (St. Louis, Mo.): A surgeon's success in the treatment of toxic goiter is measured largely by his ability to estimate accurately, preoperatively, the risk in any given case. In order to do this he must follow certain criteria of operability which, in his hands, have proved the most reliable indicators of the proper time for operation and the amount of surgery to be undertaken at that time.

I have recently completed a 15-year mortality study for toxic goiter in our private practice. The total number of thyroidectomies in this series approximates 1,500. I am presenting several slides which bring out facts learned from this study, which may prove of interest.

## COMPLICATIONS IN THYROIDECTOMY

This series, naturally, divides itself into two groups because in the first place there are about 700 cases in each and, secondly, because as a result of an earlier mortality study of the 1926-1930 group we formed our present "criteria of operability" which were applied to the second group extending from 1931-1940, with the result that we were able to cut our mortality practically in half, namely, to 1.7 per cent for the second period.

As indicated in the second illustration, we defer operation in the presence of cardiac decompensation, or if the patient is losing weight as rapidly as a half-pound a day, or if the patient is either in or has very recently been in a thyrotoxic psychosis. Likewise, operation is delayed and the medical regimen continued if the patient is vomiting; is still sweating; is having a diarrhea or if, upon repeated basal metabolic determinations, the rate is rising rather than falling. If such is the case, she is obviously in the nonsurgical phase of the cycle. Our last and most important criterion of operability is the breath-holding test, reported by my brother, Doctor Bartlett, Jr., about ten years ago. From extensive use of this test we are now able, with considerable accuracy, to determine not only whether the patient can stand an operation but also how much surgery she will tolerate without undue risk.

In the third illustration it is seen that in the first period several patients died following the second stage of two-stage procedure, whereas in the second period there was no death following a second lobectomy. This is explained by the fact that we set up the rule for ourselves, as a result of the first mortality study, that a patient must be measurably as good a risk for the second-stage as she was for the first-stage lobectomy and, if such is the case, the patient will obviously always survive the removal of the second side. I wish, also, to call to your attention that we have not performed an upper pole ligation since 1931, feeling that this procedure has very little therapeutic value and often carries a very considerable hazard for the type of patient who was previously considered sick enough to require preliminary ligation. It is our belief that the improvement obtained in some cases following ligation is due principally to the several weeks or months of additional medical management which follows the ligation but precedes the thyroidectomy, rather than to the ligation itself.

As will be noted in the last illustration, 70 per cent of the deaths in the first period were associated with crisis, while in the second period only 25 per cent (three deaths) were due to postoperative crises, which indicates quite clearly that patients are now being estimated with a high degree of accuracy preoperatively. The remaining nine deaths in the second period are largely accidental in nature and are common to any type of surgery, whether it be cholecystectomy, herniorrhaphy or thyroidectomy. We will probably never be able to avoid such incidents as pulmonary embolism, cerebral accidents, and occasional drug poisonings. Finally, I would like to point out that, since 1935, we have not only not had a death in crisis but have not had a really severe postoperative storm.

DR. HAROLD L. Foss (Danville, Pa.): As one listens to these discussions on how to handle patients with hyperthyroidism who are especially serious risks, and reads the literature dealing with the question, one is more and more impressed by the fact that there are many ways of accomplishing the same thing and doing it well. Doctor Lahey performs a high percentage of multiple-stage operations, while Richter of Chicago performs none. I am constantly resorting to stage-operations, while John Pemberton almost never utilizes the method, and so there you are!

However, the man whose mortality runs much over 4 or 5 per cent, and

who performs all his operations single-stage, is overlooking a valuable procedure. No one can question the value of ligations in selected cases in which it is clearly indicated. Improvement will be strikingly apparent in 90 per cent of the patients so treated. This whole subject was completely discussed in a paper a few years ago by Lahey and Schwalm. Some never ligate or even perform a multi-stage operation, and seem proud of it, and frequently emphasize it in discussions and in their literary contributions. They even refer to the folly of such a timorous policy and, as a remarkable thing, they seem to have a respectably low mortality record. The next group, whose mortality figures are expressed to the right of the decimal point, perform many ligations, and with their serious risk patients always resort to multi-stage operations. I stand, however, with the latter group, thoroughly agreeing with them as to the advisability, even the imperative necessity, of stage-operations in the serious risk patient with advanced hyperthyroidism.

DR. FRANK H. LAHEY (Boston, Mass., closing): Papers on thyroid disease always promote discussion. I have never heard thyroid disease discussed without its taking up a considerable period of time. Perhaps this is because it is such a satisfactory field, and also because so much progress has been made in it that it is a tribute to surgery in general. With the mortality statistics from all over the country being about the same, and when one considers what the mortality rate used to be, one may really say that it indicates definite accomplishment.

I am sure that the universal employment of one-stage operations, as advocated by some, is a dangerous plan. Thyroids are not the same, in my opinion, the world over. Thyroids in the Middle West are often, I believe, quite different from thyroids along the Atlantic seaboard. For instance, we do not live in a region where goiter is endemic, and so, practically half of our goiters are exophthalmic, and a quarter, toxic adenomata. Therefore, three-fourths of the goiters we see are toxic goiters. One must remember how different this is from Kocher's experience. When Kocher died, he had operated upon 5,000 goiters, but only about 250 exophthalmic goiters. In addition to that, realize that most of the thyroid clinics in regions where goiter is endemic, are diminishing, probably due to the fact that the employment of iodine is diminishing the number of adenomatous goiters in which toxicity can develop; while in our clinic, I am sure not due to the increasing popularity, the number of thyroids operated upon is remaining about the same.

It is important, therefore, that you do not take for gospel that you can perform 100 per cent one-stage operations on all cases. It is essential, as I have stated in the paper, that you reach a decision regarding multiple-stage operations upon your own experience and not that of others in other parts of the country. In addition to that, if you are going to make the mistake of trying to save patients time and money, be sure you have them around afterward so that they can enjoy it.

There is another kind of mistake which is made and that is in a borderline case. Do not operate upon a borderline case to prove whether or not it is a case of hyperthyroidism. If you will let the case alone it will be proven by time. Most patients will give you a clinical demonstration with time as to whether or not they have hyperthyroidism. No patient who is a borderline case is going to die, because his disease, if it is hyperthyroidism, is not that intense. If you give him time he will so demonstrate hyperthyroidism, if he has it, that you can make a clinical diagnosis without difficulty, and if he does not, in all probability he does not have it.

As relates to warnings about operating upon people with decompensation.

## COMPLICATIONS IN THYROIDECTOMY

one should recall that the thyrocardiacs, which I have stressed in the literature, are those cases which show decompensation that persists or remains stationary, in which patients cannot be made to regain their cardiac capacity. These patients often have general anasarca, ascites and even bloody sputum. These patients, I think, in spite of their decompensation, are the ones in which such brilliant results can be obtained, and not with a high mortality rate—3.6 per cent in our experience.

Another warning to stress is that while a high metabolic rate does indicate toxicity, a low rate by no means indicates safety. An additional warning we have repeatedly stressed concerns the blood iodine level. This is an expensive determination, but if one is able to do it, it is of value to realize that the low blood iodine levels in patients with hyperthyroidism do represent the bad risk cases and those in which recurrence is apt to take place.

DR. WARREN H. COLE (Chicago, closing) : I want to thank the discussers, particularly Doctor Curtis, for mentioning the question of calcium deficiency. This is relatively new, and I think we should be well aware of it and utilize calcium in our therapy. It may be extremely important in judging operability. The use of vitamins B, C and D might also be helpful.

I wish to emphasize, again, the necessity of establishing some sort of prerequisite in determining operability. This certainly will clarify operability and every now and then eliminate a postoperative death.

## PRECAUTIONS IN THE TREATMENT OF THYROTOXICOSIS\*

WARREN H. COLE, M.D.

CHICAGO, ILL.

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE, CHICAGO, ILL.

IT IS USUALLY UNWISE to resort to the utilization of fixed rules in the treatment of a disease. However, on the basis of clinical experience, and since the toxicity in thyrotoxicosis can be measured so definitely by clinical and laboratory means, it appears that this disease may be an exception. Some of the precautions to be utilized are so concrete that they can actually be placed on a mathematical basis.

*Diagnosis.*—It is not the purpose of this presentation to discuss the manifestations, but the necessity of making an accurate diagnosis must be emphasized. The frank and typical case of thyrotoxicosis can be diagnosed readily. The mildly toxic cases, however, may be simulated by numerous diseases including pulmonary tuberculosis, leukemia, endocarditis, neurocirculatory asthenia, etc. When the diagnosis is doubtful the patient should be examined thoroughly with the idea of eliminating such diseases. The seriousness of performing a thyroidectomy, when the manifestations are really produced by one of these other diseases, need not be emphasized. Perhaps the condition most apt to be confused with mild hyperthyroidism, is neurocirculatory asthenia. In this disease the nervousness, tachycardia, loss of weight, weakness, sweating, etc., may be identical with that encountered in thyrotoxicosis. There will not be enlargement of the thyroid; a point, however, which does not eliminate entirely the possibility of thyroid disease. If other features fail to differentiate the two diseases, very reliable information can be obtained by noting the response to iodine. If the patient is put on routine Lugol's therapy and does not respond as do patients with hyperthyroidism, the diagnosis of neurocirculatory asthenia will be more likely. Another disease readily confused with early hyperthyroidism is hypertension, because manifestations including tachycardia, hypertensive palpitation, "nervousness," elevated basal metabolic rate, etc., as has been emphasized recently by Crile and McCullagh,<sup>1</sup> are common to both diseases. However, it should be remembered that the two diseases may be present simultaneously; Bisgard<sup>2</sup> noted that in a series of 265 cases of thyrotoxicosis, essential hypertension was present in 8 per cent of the cases. The degree of toxicity in patients with a doubtful diagnosis is always mild. Little or no harm can, therefore, result from delay in radical treatment; with observations during this period of delay, the diagnosis will, with very few exceptions, become established.

*Preoperative Treatment.*—If the diagnosis of thyrotoxicosis is made,

\* Presented at the Fifty-third Annual Session of the Southern Surgical Association, Hot Springs, Va., December 11, 1940.

## TREATMENT OF THYROTOXICOSIS

a decision must be made as to the type of therapy to employ. Obviously, it may be medical or surgical. Nevertheless, as years go by, with such favorable results reported following surgical treatment, fewer reports on medical treatment are encountered in the literature. In medical treatment, roentgenotherapy is an important feature. It seems to be the consensus of opinion, however, that although roentgenotherapy will frequently result in marked improvement of symptoms for a period of time, it is rarely curative. It is true, however, that there is a small group of patients with the diagnosis of mild hyperthyroidism, presumably accurately made, who need not be subjected to thyroidectomy. I have in mind particularly a group of young people, who have accepted, or had thrust upon them, an unusual amount of activity or worry, and have developed symptoms of hyperthyroidism incident to this sudden change in their routine way of living. Not infrequently, removal of the source of mental and physical strain, with an increase in the amount of rest and sleep will result in a cure without thyroidectomy.

The following measures should be adopted in principle in the treatment of all cases of hyperthyroidism, but apply particularly to those with moderately severe toxicity:

(1) *Administration of Iodine.*—The advantages of iodine administration, particularly in preparation of the patient for thyroidectomy cannot be disputed. Ordinarily it is given in the form of Lugol's solution 5 to 15 M. three times a day. In mild cases, the patient may, and should be treated in an ambulatory fashion; hospitalization should be reserved for severely toxic patients, as will be discussed later. Although the maximum benefit appears in 10 to 12 days, it is commonly preferable, particularly in the severely toxic group to continue therapy several days longer before operation. Patients who have had prolonged treatment of iodine are frequently problems in therapy. The author agrees with Lahey,<sup>3</sup> that in patients who are severely toxic, not ready for operation, it is preferable with few exceptions to maintain hospitalization awaiting remission, rather than to discontinue Lugol's solution and send them home. In a study of results following therapy with lugolization over a varying length time, Lehman and Shearburn<sup>4</sup> were unable to find much relationship of the duration of iodine therapy (beyond the period of maximum benefit) to results.

(2) *Control of Physical Activity.*—Patients under treatment for thyrotoxicosis should stop working, particularly if physical exertion is required. Mild activity, requiring little exertion, and serving to occupy the patient's mind for a few hours during the day is acceptable and frequently advisable. Patients with a mild or moderate degree of toxicity should not be confined to bed during the period of preoperative preparation with iodine because of the constant weakness produced by it; they may, in fact, be treated as ambulatory patients, keeping them in the hospital for two or three days before operation to accurately establish their degree of toxicity. Bed rest in the hospital is reserved for patients with severe toxicity or those with cardiac decompensation.

(3) *Elimination of Worry and Psychic Trauma.*—It is exceedingly important in patients with severe toxicity that they be removed from an atmosphere creating emotional disturbance. They should be segregated from illness in the family, financial worries and other family troubles as much as possible. Moreover, severely toxic patients should not be informed as to the date of operation. They may be told that an operation will be necessary at some future date but a responsible relative should be informed as to the exact date of operation.

(4) *Sedation.*—Since sleeplessness is one of the cardinal symptoms of hyperthyroidism, sedatives are definitely indicated. Barbiturates (*e.g.*, phenobarbital in a dose of  $\frac{1}{2}$  gr. two or three times daily) are the most popular. Daniels<sup>5</sup> has expressed the opinion that they actually have an antagonizing effect upon the action of the thyroid on the brain; but this point is not proven. However, barbiturates depress the basal metabolic rate of animals and human beings, whereas morphine is not as effective in this respect.

(5) *Increased Food Intake.*—It is extremely essential that the caloric intake be raised to the point where a *weight gain* is registered. Naturally, the amount of food required for this will depend, to a great extent, on the degree of toxicity. Not infrequently an intake of less than 5,000 calories will not be sufficient to bring about a gain in weight. This represents a large intake; but since an increased appetite is a manifestation of hyperthyroidism, these patients are usually able to take that amount. Part of this quantity will have to be ingested between meals and at bed-time, in the form of light food. Theoretically, the diet should not be very high in proteins, on account of the specific dynamic action of proteins. However, the author agrees with Womack<sup>6</sup> that the good effects resulting from a large amount of protein in the diet more than neutralize the increased metabolism resulting from the specific dynamic action. Naturally, adequate fluids must be maintained. Of the vitamins beneficial in hyperthyroidism, A and B<sub>1</sub> are perhaps most important. Their beneficial action is probably dependent upon the increased needs incident to the elevation of the basal metabolic rate. For the most part, it is probable that a properly balanced diet in the large quantities mentioned above would contain adequate vitamins.

(6) *Treatment of Complicating Diseases.*—Thyrotoxicosis is not infrequently associated with diabetes. In spite of the fact that the presence of diabetes would increase the mortality rate to some extent, the indications for thyroidectomy are about as great as in a patient with uncomplicated hyperthyroidism. It appears to be the consensus of opinion that thyroidectomy for toxic goiter in the presence of diabetes markedly improves the carbohydrate metabolism. It should be emphasized, however, that thyroidectomy should not be performed until the degree of diabetes and the amount of insulin required are firmly established. Cardiac decompensation is frequently encountered in thyrotoxicosis (particularly the type associated with nodular goiter), and, in reality, is a strong indication for thyroidectomy with removal of most, if not all of the thyroid on each side. However, operation should

## TREATMENT OF THYROTOXICOSIS

not be performed while the patient has acute decompensation with edema and ascites. With adequate rest and medical care, including the use of digitalis, salyrgan, etc., the patient will be brought around within a week or two to a condition considered as a fair operative risk.

*Miscellaneous Therapy.*—In view of the recent observations of Curtis, and associates,<sup>7</sup> in which they showed that a definite negative calcium balance exists in hyperthyroidism (particularly the toxic diffuse type), calcium therapy would appear indicated. Patients with severe hyperthyroidism should be given intravenous glucose preoperatively on the morning of operation.

*Prerequisites for Operation.*—It is probable that each surgeon has a set of prerequisites of his own, which he utilizes in determining operability in thyrotoxicosis. Although there may be individual variations, the principles will be identical. Some of these prerequisites are so definitely understood, and agreed upon, that they can actually be listed on a mathematical basis. It should be emphasized, however, that each patient, in the long run, must be looked upon as an individual problem, and all features analyzed before arriving at important decisions regarding operation, etc. The prerequisites (i.e. for bilateral thyroidectomy), as utilized in this clinic, may be listed as follows:

(1) *Gain in Weight* is, unquestionably, the most important prerequisite for operation in patients with severe thyrotoxicosis. Under no circumstances should a patient with a significant degree of toxicity be subjected to operation without observations on the weight of the patient demonstrating a definite gain. As stated previously, the amount of food may have to be increased to an intake of 5,000 calories before a satisfactory gain in weight can be produced. Rarely, indeed, will the thyroid patient fail to gain if the caloric intake is adequate. If he is quite toxic and fails to gain, operation must be postponed until the various procedures in conservative treatment, including perhaps roentgenotherapy, have been utilized. In patients who have lost considerable weight, a simple gain in weight itself will not be sufficient. It can be stated, definitely, that these patients should have regained a major part of their loss, which may amount to 30–35 pounds. Unquestionably, the danger of ill effects from prolonged iodine medication will be more than neutralized by the improvement in the patient's physical condition incident to a marked gain in weight.

(2) *The Resting Pulse Rate Should Be Below 110.*—Obviously, temporary exertion and emotional strain will increase this rate. If a moderate amount of mental or physical activity elevates the pulse rate very far above this level, this one factor may be an important indication that the optimum physical condition has not been attained. Obviously, the pulse rate will not be of value in patients who have auricular fibrillation. So often, however, in patients who have cardiac damage of that degree, the amount of thyrotoxicosis is mild, therefore, allowing one to utilize the state of cardiac compensation as the important factor in determining operability.

(3) *The Basal Metabolic Rate Should Be Less Than 50 Per Cent Above Normal.*—Naturally, this prerequisite is somewhat empiric, particularly, because the basal metabolic rate is frequently inaccurate, not actually depicting the degree of toxicity. However, it can be safely said that patients with a metabolic rate much above 50 at the time of operation are apt to have a stormy postoperative course.

(4) *Administration of Iodine* should extend over a period of at least two weeks, particularly in the group of patients whose toxicity is above average. Although the so-called optimum level may appear to be reached a few days earlier, the author is convinced that operability will frequently be markedly improved by delay.

(5) *Improvement in Symptoms* must take place following iodine administration and other therapeutic measures. Improvement in symptoms is, to a great extent, an index of favorable reaction to lugolization. If the thyroid gland has failed to absorb iodine, with consequent amelioration of symptoms, postoperative reactions will commonly be encountered. Moreover, in patients whose diagnosis is uncertain, the failure of response to iodine may indicate, strongly, that the diagnosis of thyrotoxicosis is incorrect.

Rarely will it be justified to break the above rules. There will be occasions, however, when patients will be so toxic and will respond so poorly that they cannot be brought down to a level which meets these requirements. Occasionally we have noted that all of these five prerequisites cannot be met. In this case, if the other four prerequisites are met, with a reasonable margin of safety, we assume that the one out of line will have been neutralized. We are very reluctant, however, to undertake operation if more than one of these prerequisites cannot be met. Obviously in these doubtful cases the question of excision of only one lobe will arise. This problem is discussed later.

The decision as to *time of operation*, therefore, becomes one of the most important problems in the treatment of severe thyrotoxicosis. It is a safe axiom to always postpone operation when there is doubt as to operability, since, with prolonged care remissions are bound to take place and operability, therefore, will be improved. Naturally, when severe cardiac damage is being inflicted by the thyrotoxicosis, delay will be detrimental to the heart. However, as stated previously, in these patients with severe cardiac symptoms the toxicity is usually diminished to a point where the question of operability is determined by the state of cardiac compensation. When severe toxicity exists, there should be no hesitancy in sending patients back to the ward from the operating room, if it appears that they have not reacted properly to the psychic shock of preparation for operation. For example, if a tachycardia of 130 or 140, produced by transportation to the operating room, etc., does not come down to 120, or thereabouts, under anesthesia, it may be preferable to send the patient back for further medical care. On the other hand, it might appear that the patient would be a safe subject for removal of one lobe only.

## TREATMENT OF THYROTOXICOSIS

Wt. gain - 10 lbs.  
Resting pulse 112  
(very labile)  
B.M.R. + 48

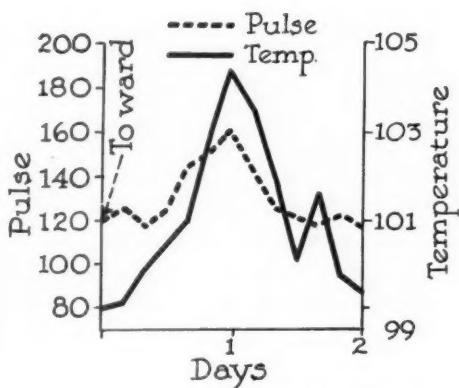
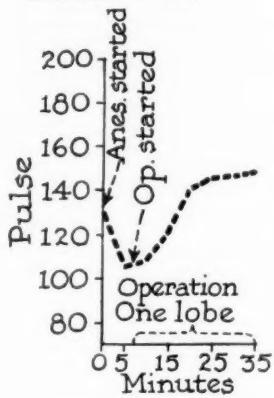


CHART 1.—The graph on the left shows the pulse rate during operation upon a fairly toxic patient, requiring a lot of oxygen during the anesthesia. In view of the elevation of pulse rate and high oxygen consumption, only one lobe was removed. The temperature and pulse curve on the right, indicative of a moderate crisis, suggests that more operative work might have resulted in a crisis threatening life.

Wt. gain - 10 lbs.  
Resting pulse 104  
(stable)  
B.M.R. + 45

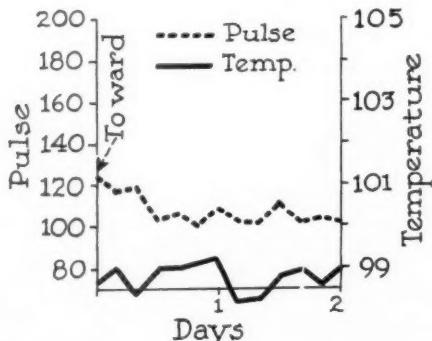
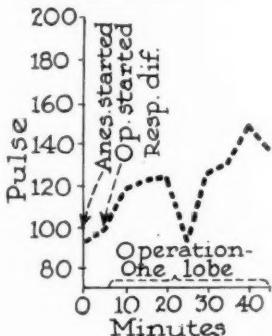


CHART 2.—The graph on the left shows the pulse rate of a patient (slightly less toxic than the patient in Chart 1) during operation. Respiratory difficulty due to laryngeal spasm was very troublesome throughout. The sharp temporary drop in heart rate occurred when cyclopropane was begun in an effort to increase the percentage of oxygen in the gaseous mixture. The pulse rate continued to rise. We were unable to tell whether the increasing tachycardia was due to toxicity or anesthesia complications, but decided it was preferable to remove only one lobe. The relatively quiescent postoperative course suggests the tachycardia during operation was more related to anesthesia complications than to toxicity.

*Anesthesia.*—The author agrees with Lahey<sup>3</sup> that local anesthesia is undesirable, particularly in patients who exhibit more than a moderate degree of toxicity. Naturally, when mild toxicity is present, local anesthesia will not instigate the development of sufficient psychic trauma to jeopardize the patient's condition. On the other hand, when the patient exhibits a marked degree of toxicity, he may suffer sufficient psychic trauma to produce a pronounced tachycardia and other manifestations sufficiently severe to actually jeopardize his operability. It is remarkable to note how often anesthesia will control the tachycardia which develops during preparation for operation. In this clinic we prefer ethylene as the anesthetic agent. Lahey uses cyclopropane in the majority of cases. Water<sup>8</sup> uses nitrous oxide to a great extent, but states that if conditions are not satisfactory under this agent he is prepared to resort to a different one. Since nitrous oxide anesthesia prevents the use of a very high concentration of oxygen, it will, naturally, require more skill in its administration. It should be emphasized, very strongly, that cyanosis is a complication to be avoided. Although it may occur from time to time during the operation, the anesthetist should be acquainted with the fact, and resort to active measures to correct it. If anoxia is severe, and is allowed to persist over a long period of time, it is even possible that permanent cerebral damage may result. Degenerative changes have been noted experimentally in animals by Thorner and Lewy<sup>9</sup> after repeated anoxia. By careful observation and cooperation with the anesthetist, it is usually possible to determine from the patient's breathing (under ethylene anesthesia) when the recurrent laryngeal nerve has been damaged. Obviously, if the damage is incident to pressure of an hemostat, removal of the clamp will correct the condition. If the damage consists of sectioning of the nerve, immediate repair will be indicated.

On certain occasions intratracheal intubation will be distinctly indicated. In all patients who have a significant degree of tracheal obstruction, it is usually preferable to insert a tube in the trachea, after anesthesia is obtained. If respiratory difficulty is encountered during induction, and cannot be corrected, such a patient will, likewise, be a candidate for intratracheal anesthesia. It should be emphasized, however, that the surgeon is handicapped slightly by the presence of the intratracheal tube, because he will be unable to detect when clamps may have been put on, or too near, a recurrent laryngeal nerve. The tube should be taken out before the wound is closed, to be certain that the airway is patent. If the nerves have been injured it may be necessary to perform an immediate tracheotomy. Obviously, if this is not discovered until the wound is closed, so much time may be lost in performing the tracheotomy as to jeopardize the patient's life.

The proper administration of premedication drugs is important in allaying apprehension and making smooth anesthesia possible. We favor giving 1.5 gr. of phenobarbital the evening before operation, and giving morphine grain  $\frac{1}{4}$ , with scopolamine grain 1/150, about one hour before operation. If toxicity is severe more morphine can be given later. As a basal anesthesia,

## TREATMENT OF THYROTOXICOSIS

eliminating psychic shock produced by preparations for operation, avertin (rectally) may be given to patients, unless severe toxicity exists. However, in a study<sup>10</sup> made in this clinic, on the effects of avertin, it appeared that the drug actually reduced the operability by increasing the pulse rate, *etc.* We abandoned its use and believe that it, particularly, should not be given to patients with severe toxicity.

*Extent of Operation.*—Since the advent of iodine in the preoperative treatment of thyrotoxicosis most surgeons have abandoned polar ligation, with the idea that removal of a single lobe (followed by removal of the other lobe in about six weeks) may be substituted for that procedure. As previously implied, the pulse rate and its response to physical activity, *etc.*, will be an important indication as to the patient's toxicity. The author is of the opinion that pulse rate is perhaps the most important single factor in determining operability, and the possibility of severe postoperative reaction. If there has been difficulty in obtaining a sufficient improvement in the patient's symptoms to make operation safe, a decision can often be made preoperatively that the operation should be done in stages, removing a lobe at a time. If the patient's condition has been so questionable as to lead one to this conclusion, it will rarely be justified to change the opinion during the operation in favor of a bilateral lobectomy, even though the patient's condition through the operation seems satisfactory. If the patient's pulse rate does not come down to 120, or thereabouts, under anesthesia, or if it makes frequent excursions to a higher level, without explanation from the standpoint of anesthesia, the patient's *operability for a bilateral lobectomy will be in question.* Under such circumstances it will obviously be wise to remove only one lobe. There are a few surgeons (Richter, and associates<sup>11</sup>) who are of the opinion that operation in two stages does not diminish the dangers incident to operation, and does not reduce mortality rate. Lahey is probably one of the strongest advocates of the two-stage procedure, utilizing it in approximately 22 per cent of his cases. Considerable argument arises as to the amount of tissue to be removed. It appears safe to state that in patients who are mildly toxic and who have a very large goiter, the thyroidectomy need not be very complete. In such instances several grams of tissue may be left on each side without the danger of recurrence. In patients who have a relatively small gland, but whose toxicity is pronounced, the thyroidectomy must be fairly complete, leaving no more than 1 or 2 Gm. of tissue on each side along with the posterior capsule. It is, of course, well-known that recurrence is extremely uncommon in toxic nodular goiter. However, persistence of toxic symptoms can readily take place in this disease, explained by the fact that insufficient tissue was removed. Cattell and Morgan<sup>12</sup> have called attention to the fact that in recurrent thyrotoxicosis, the excision of glandular tissue must be more complete. In fact, if nerves and the parathyroids can be avoided, it is fairly safe to direct the operation toward a complete thyroidectomy, assuming that a few shreds of tissue will be left with the posterior capsule.

*Precautions In Technic.*—Although there is an obvious indication for completion of the operation in as short a time as possible, it should be emphasized that carefulness must not be sacrificed for speed in the operative procedure. Moreover, the teachings of Halsted have convinced us that gentle handling of tissue with careful technic in ligation of blood vessels, etc., will pay good dividends in results including mortality rate. Only occasionally will it be necessary to cut the sternohyoid muscle transversely. However, when exposure is poor, the surgeon *should not hesitate* to do so; by so doing many difficulties and accidents will be prevented. If the operator has decided to undertake a fairly complete thyroidectomy extreme care must, naturally, be taken lest the recurrent laryngeal nerves be injured. To counteract this possibility through accident, Lahey isolates the nerve in every case. The author, however, does not employ this routine. When thyroidectomy is fairly complete, all nodules of tissue resembling parathyroid bodies should be transplanted back into the wound. All ligatures, particularly of the large vessels, should be tied securely. In fact, it is a fairly safe routine to put a double ligature on the superior pole, and the major branch of the inferior thyroid artery. Silk or catgut may be used for ligature. The author, however, prefers the use of silk, largely because drainage can be eliminated, and because wounds as well as postoperative reaction will be improved sufficiently to allow the patient's discharge at an earlier date. The most serious errors in technic are injury to the nerve, excision of parathyroids, and removal of inadequate thyroid tissue. Perhaps the most serious of these three errors is injury to the recurrent laryngeal nerve, particularly if it is bilateral. Damage to nerves will be greatly minimized if the surgeon changes his position from the patient's right to left, as he proceeds from excision of the right to left lobe, particularly if exposure is poor. Injury of one nerve will not produce complete respiratory obstruction, but is apt to result in hoarseness or loss of voice with only mild obstruction to breathing. Occasionally, no symptoms are noted by the patient, although laryngoscopic examination may reveal one cord to be paralyzed. If both nerves are injured the resultant bilateral paralysis will result, almost invariably, in complete obstruction to breathing, requiring an immediate tracheotomy. Up to a few years ago, very little could be offered to these patients. Rarely could the tracheotomy tube be removed. A short time ago, Hoover<sup>13</sup> reported relief of the respiratory obstruction by submucous resection of the cord. A much more promising procedure, however, is that recommended by King,<sup>14</sup> consisting of dislocation of the arytenoid cartilage with fixation by suture so that the cord is pulled away from the midline. From preliminary results, it appears that this operation will be successful in eliminating respiratory obstruction in the vast majority of cases of bilateral nerve injury.

*Postoperative Treatment.*—Before leaving the patient, the anesthetist returning with him must be certain that the air-way is open, and that the patient is breathing without difficulty. The bandage should be inspected to be sure that it is not applied too tightly, an error which is apt to be encoun-

## TREATMENT OF THYROTOXICOSIS

tered, not infrequently, because of the haste with which they are frequently applied in the operating room.

(1) *Position in Bed.*—The patient should be placed in a semisitting position with the back-rest up. This will be much more comfortable for him than lying down, and will facilitate swallowing. It also aids considerably in breathing.

(2) *Intravenous Fluids.*—All patients with toxicity should have intravenous glucose started immediately upon return to the ward. The amount will depend upon the degree of toxicity. If they are only mildly toxic, 1,000 cc. of 5 per cent solution will be sufficient. If toxicity is fairly severe, 3,000 cc. of 5 per cent will be indicated for the day of operation. It is given in decreasing amounts for the first one or two days postoperatively—the quantity determined by the degree of toxicity and amount of fluid and food taken by mouth.

(3) *Oral Fluids.*—Although there will be slight discomfort incident to swallowing, with slight urging the patient will be able to do so, and after a few attempts will swallow without significant discomfort. Cold fluids, consisting largely of sweetened fruit juices, should be allowed immediately after operation, as tolerated. In our experience, oral fluids cannot entirely displace intravenous fluids, yet they are given in as large quantities as will be tolerated. Rarely will the patient be able to take more than 1,000 cc. the day of operation.

(4) *Administration of Lugol's Solution.*—It is not certain just how much benefit is obtained by the postoperative administration of iodine. However, when a subtotal thyroidectomy is performed, leaving a small amount of thyroid tissue, it is the consensus of opinion that iodine should be given postoperatively. In this clinic, a large dose, consisting of 5 cc. is given rectally in 200 or 300 cc. of water. In addition, the patient is placed on 10 M. three times a day for a few weeks until all evidence of hyperthyroidism has disappeared.

(5) *Watch for Respiratory Difficulty.*—Respiratory difficulty represents one of the serious emergencies in postoperative care. If it is not recognized early, a fatality is apt to result. It may be caused by either one or two complications, namely, (1) postoperative hemorrhage; or (2) injury to the recurrent nerves. If a postoperative hemorrhage has developed, the first demonstrable evidence is usually difficulty in breathing. If a drain has been placed in the wound there will be considerable blood on the dressing, but rarely does the drain prevent compression of the trachea in vigorous bleeding, because clots form and block the exit. Early in the postoperative hemorrhage, inspection of the wound will reveal nothing more than slight swelling, which *will not be detected* by an inexperienced intern. As the hemorrhage progresses the respiratory obstruction will increase to the point where cyanosis appears. This is a *late symptom and demands immediate action* to prevent a fatality. The wound should be opened and the clot evacuated. The bleeding point is then found and ligated. If unable to find the bleeding

point, gauze should be packed into the operative field with the wound left open. If the emergency treatment has been delayed, tracheotomy will frequently be necessary, presumably because of edema and extravasation involving the nerves. This adds an additional source of danger because of infection of the wound which is apt to result. If the respiratory difficulty is associated with bilateral nerve injury, tracheotomy will almost invariably be necessary. If the patient was breathing satisfactorily upon return to the ward, but developed respiratory obstruction a few hours later, it is safe to assume that both nerves had not been severed; edema may produce this complication with or without injury to one nerve. Tracheotomy may still be necessary, particularly if the obstruction is sufficient to produce cyanosis. There is a great tendency to delay tracheotomy too long. It is a well-known fact that if the patient is to be saved it must be performed early, before cyanosis has been present very long.

(6) *Oxygen Therapy for Tachycardia*.—If the patient's toxicity is sufficient to produce a tachycardia above 130 to 140, postoperatively, oxygen therapy will be strongly indicated. It has been our experience that tachycardia can be reduced appreciably by oxygen therapy. If the cardiac embarrassment is sufficient to produce cyanosis, oxygen therapy becomes even more urgent. It may be administered in one of three ways: (1) By intranasal catheter; (2) by mask; and (3) by tent. The intranasal method is so simple that we employ it almost to the entire exclusion of the other procedures. Occasionally, the presence of the catheter or tube in the nose will be a source of considerable discomfort. If it produces nausea and vomiting, the tube will be found to be protruding too far posteriorly. If this method is uncomfortable, either a mask or tent may be used. If an oxygen tent is used, the situation must be explained carefully to the patient lest he consider the procedure a symbol of impending death, and work himself into a serious state of psychic shock through worry. Occasionally cyanosis will develop solely because of cardiac damage in the absence of significant toxicity. Such a situation will be encountered chiefly in the elderly patients, suffering from toxic nodular goiter, with cardiac symptoms of many months' or years' duration.

(7) *Sedation*.—All patients during the first few days, postoperatively, must be given sufficient phenobarbital, morphine, etc., to insure rest and sleep, particularly at night. It has been our experience that patients with moderately severe thyrotoxicosis will have their symptoms exaggerated markedly if they are not given ample morphine to insure sleep the first one or two postoperative nights. Because of the increased basal metabolic rate these patients will be able to tolerate larger and more frequent doses of morphine than the average individual. A daily dose of a sedative such as phenobarbital is just as important during the first few postoperative days as in preoperative treatment; after the first night or two it should supplant morphine. The patient will have to be watched closely to determine what the optimum dose of sedatives should be. Obviously, any dose of morphine which depresses the respiratory rate is too large. If an overdose is given

## TREATMENT OF THYROTOXICOSIS

cyanosis may develop and be a serious complication. If this occurs, oxygen therapy must be instituted at once.

(8) *Miscellaneous Procedures.*—It is extremely important that the patient be kept cool, and not have too many covers. There is a great tendency on the part of nurses to cover patients with too many blankets upon arrival from the operating room. Keeping the patient warm is, of course, an important precaution in the average postoperative patient, but in hyperthyroidism, the heat production is already so pronounced that the application of more than a light blanket will tend to result perhaps in actual heat stroke, particularly in warm weather. Naturally, a patient with severe toxicity should not be submitted to thyroidectomy on a hot day. If the weather suddenly turns hot, it will be necessary to use ice-bags, electric fans, etc., or even an air-conditioned room. The patient should be placed in a room by himself if possible, but this is by no means necessary. Perhaps the only precaution of importance in this respect is that he not be placed next to a moribund patient, or one complaining bitterly. At times, the presence of calm patients next to the patient seems to add to his comfort, particularly if adequate sedation is given for rest and sleep at night.

All patients should be watched for the development of tetany. Early symptoms would be numbness and tingling of the hands, positive Chvostek's sign, carpopedal spasm and awkwardness in using the hands. If tetany develops, the immediate administration of calcium is indicated. It is commonly given intravenously as calcium gluconate, in doses of 5 cc. of 10 per cent solution two or three times daily as indicated. If calcium therapy along with inclusion of milk in the diet does not relieve the patient, parathormone will be necessary. One ampule three times a day will suffice even in severe cases. During the postoperative convalescence the wound must be watched for complications other than hemorrhage, as already discussed. Naturally, if an infection develops the wound must be opened and drainage established. If serum collects, it should be aspirated since its accumulation will encourage the development of infection. Infection will be much less frequent when silk has been used but will be more serious. We have had a few instances of infection with prolonged drainage in our patients in whom silk was used, but none who drained longer than a few weeks; exploration of the wound with removal of two or three sutures may at times be indicated.

*Treatment of Crisis.*—Naturally, the most important feature in the treatment of crisis is prophylactic, insofar as a patient developing a crisis is usually so toxic that operation should not have been performed at that time. There is no question but that hot and humid weather increases the tendency toward the development of crisis postoperatively. As noted above, severely toxic patients must not be submitted to operation on hot days. If this cannot be avoided the patient should be treated with ice-bags, electric fans, etc., or preferably placed in an air-conditioned room, immediately upon return from the operating room. If crisis has developed this feature in therapy becomes more important, and in the author's estimation is the most important factor in therapy. Naturally, an air-conditioned room is preferable but not

necessary, if the beneficial effects of ice-bags, wet towels, and electric fans are taken advantage of. One need not fear the development of pneumonia in these patients, by the application of innumerable ice-bags and wet towels. The amount of sedatives required will be increased over that in the average patient. In addition to morphine, it is usually advisable to give an additional sedative such as phenobarbital (perhaps the soluble sodium salt hypodermically). The fluid intake must likewise be increased, up to at least 5,000 cc. per day, depending upon the patient's temperature. These patients will rarely be able to take much by mouth, and even if they do, will probably vomit most of it. It will, therefore, be necessary to administer most of the fluid intravenously as 5 or 10 per cent glucose. This is absolutely essential, and no excuses to the contrary are acceptable, except in severe cardiac decompensation, which in reality is rarely seen in crisis except as a terminal manifestation. An attendant may have to be assigned to holding the patient's arm, but in our experience, the arm can be fixed adequately with bandages, etc., even though the patient is mildly delirious. Oxygen therapy, as previously described, is extremely important, and should be instituted as soon as impending crisis is detected. Sodium iodide should be given intravenously in doses up to 1 Gm., once or twice a day as indicated.

COMMENT.—Since the advent of iodine in the preoperative care of thyrotoxicosis, very few instances of crisis are observed postoperatively. As stated previously, if a crisis develops, it can be said, definitely, that an error has been made in the date or extent of operation. In spite of all precautions, there undoubtedly will be a small mortality rate, perhaps as high as two- or three-tenths of 1 per cent, because of unpreventable accidents. The incidence of natural death alone in a large series of patients during several days' hospitalization will in itself prevent establishment of a mortality rate of zero except by coincidence. Moreover, occasionally, complications will develop which are in reality secondary to the operation but which appear unpreventable.

The higher mortality rates as reported in the South over the figures in the North are difficult to explain. At first glance, it would appear to be related to the higher incidence of Negroes in the thyrotoxic patients. This explanation is not clear-cut for several reasons. For example, in one series in the South, the highest mortality rate was encountered in Negro females, whereas in another series (Maes and Romano<sup>15</sup>) the highest mortality was encountered in Negro males. Moreover, in our series of 478 thyroidectomies for toxic goiter, as performed during the past four and one-half years, we had no deaths, whatsoever, in the 42 Negro patients in that series; it is possible, of course, that the Northern Negro is better nourished than the Southern Negro. It would appear then that longer preoperative therapy would be indicated, and that weight gain *must be greater* than in the average patient.

In our series of 581 operations (Table I), we had six deaths, with a mortality rate of 1.03 per cent for the entire series. Of this group, how-

## TREATMENT OF THYROTOXICOSIS

TABLE I  
TYPES OF GOITER AND MORTALITY (1936-1940)

Type	Operations	Deaths	Mortality
Toxic-diffuse	277	3	1.08%
Toxic-nodular	201	3	1.44%
Nontoxic-nodular	103	0	0
Total	581	6	1.03%

In toxic group 42 Negroes (9 per cent)—no deaths.  
All six deaths were in white females.

ever, 103 were nontoxic, making the mortality rate for the 478 toxic patients 1.25 per cent. In the toxic series, we resorted to a two-stage operation in 7.5 per cent of the cases. In a goiter belt, where there is such a high percentage of patients with an initial basal metabolic rate of above 50, this incidence of 7.5 per cent is probably too low. In the group of 581 cases submitted to thyroidectomy only 18 per cent were nontoxic nodular goiters. This is perhaps not an accurate estimation of the incidence of nontoxic nodular goiter in the Chicago area, since our hospital is too small to care for all of our dispensary patients, and preference for hospitalization is given to the toxic group.

Of six patients dying following operation, two succumbed to crisis; one to gas gangrene of the buttocks; one to postoperative hemorrhage; one to tetany; and one to acute hepatitis. All of these deaths were in white women. At least half of them were preventable including, particularly, the two patients in crisis, and the patient dying from postoperative hemorrhage. Neither of the two patients dying from crisis fulfilled the prerequisites as outlined herein. In retrospect, therefore, we classify them as errors in the choice of time of operation. There is, perhaps, no doubt that the patient who died from hemorrhage into the neck wound, could have been saved by more careful observation postoperatively, with opening of the wound, evacuation of the clot, etc. The operations in the entire series were performed by 12 different surgeons.

Undoubtedly, hepatic insufficiency is a contributing cause of death in many instances. The presence of cellular necrosis of the liver in patients dying of thyroid disease has been known for decades. Boyce and McFetridge<sup>16</sup> have shown that tests of hepatic function (hippuric acid test) indicate the presence of hepatic insufficiency in a great percentage of thyroid patients. In a series of 24 fatal cases of toxic thyroid disease, as reported by Shaffer,<sup>17</sup> there was an average decrease in weight of the liver of slightly over 300 Gm. in the patients dying of thyroid disease. However, in a study of patients dying from thyrotoxicosis, Foss, and associates<sup>18</sup> were unable to find a very direct relationship of the amount of hepatic damage to the severity of the crisis.

## SUMMARY

The most important features in lowering mortality rate in thyroidectomy for toxic goiter consist of adequate preparation of the patient, and choice of

time for the operation. Postoperative care, as well as the extent of the operation (*i.e.*, one- or two-stage operation), are likewise important. By adhering to certain principles it seems definite that mortality can be kept low (1 per cent or less), by eliminating all of the deaths from crisis, and many of the deaths resulting from complications in the presence of a mild crisis. It is impossible to make several rules apply to each individual patient. In general, however, we utilize gain in weight, basal metabolic rate of below 50, resting pulse rate below 110, and response to iodine, as prerequisites for operation. If these prerequisites cannot be met, it will be necessary to postpone operation awaiting a remission, or to submit the patient to removal of one lobe only. Intravenous glucose is extremely important in the post-operative care, and should be instituted in all patients, except perhaps those with very mild toxicity.

## REFERENCES

- <sup>1</sup> Crile, George, Jr., and McCullagh, E. P.: Hypertension Simulating Hyperthyroidism. *Med. Clin. North America*, **24**, 395, 1940.
- <sup>2</sup> Bisgard, J. D.: Relation of Hyperthyroidism to Hypertension. *Arch. Int. Med.*, **63**, 497, 1939.
- <sup>3</sup> Lahey, F. H.: The Surgical Treatment of Thyroid Disease. *New Eng. Jour. Med.*, **221**, 978, 1939.
- <sup>4</sup> Lehman, E. P., and Shearburn, E. W.: Thyrotoxicosis. *ANNALS OF SURGERY*, **109**, 712, 1939.
- <sup>5</sup> Daniels, L. P.: On the Significance of the Various Phenomena of Basedow Complex. *Acta Med. Scandinav.*, **98**, 561, 1939.
- <sup>6</sup> Womack, N. A.: Preoperative and Postoperative Treatment of Toxic Goiter, *Arch. Surg.*, **40**, 1123, 1940.
- <sup>7</sup> Puffel, I. D., Klassen, K. P., and Curtis, G. M.: Calcium Metabolism in Thyroid Disease. The 1939 Transactions of the Amer. Assn. for Study of Goiter, **221**; Puffel, I. D., and Curtis, G. M.: *Arch. Int. Med.*, **58**, 957, 1936.
- <sup>8</sup> Waters, Ralph: Personal communication.
- <sup>9</sup> Thorner, M. W., and Lewy, F. H.: The Effects of Repeated Anoxia. *J.A.M.A.*, **115**, 1595, 1940.
- <sup>10</sup> Cole, W. H., and Brunner, Robbie: Anesthesia in Thyroidectomy for Thyrotoxicosis. *Surg., Gynec., and Obstet.*, **70**, 211, 1940.
- <sup>11</sup> Richter, H. M., Mora, J. M., and Wagner, D. H.: One-Stage Thyroidectomy for Thyrotoxicosis in Aged. *Surg., Gynec., and Obstet.*, **69**, 178, 1939.
- <sup>12</sup> Cattell, R. B., and Morgan, E. S.: Recurrent Hyperthyroidism. *Surg., Gynec., and Obstet.*, **68**, 347, 1939.
- <sup>13</sup> Hoover, W. B.: Bilateral Abductor Paralysis: Operative Treatment by Submucous Resection of the Vocal Cords. *Arch. Otolaryng.*, **15**, 339, 1932.
- <sup>14</sup> King, B. T.: A New and Function-Restoring Operation for Bilateral Abductor Cord Paralysis. *J.A.M.A.*, **112**, 814, 1939.
- <sup>15</sup> Maes, N., and Romano, S. A.: Thyroid Disease in a Nonendemic Area. *ANNALS OF SURGERY*, **111**, 275, 1940.
- <sup>16</sup> Boyce, F. F., and McFetridge, E. M.: Studies on Hepatic Function by the Quick Hippuric Acid Test. *Arch. Surg.*, **37**, 427, 1938.
- <sup>17</sup> Shaffer, J. M.: Disease of the Liver in Hyperthyroidism. *Arch. Path.*, **29**, 20, 1940.
- <sup>18</sup> Foss, H. L., Hunt, H. F., and McMillan, R. M.: Pathogenesis of Crisis and Death. *J.A.M.A.*, **113**, 1090, 1939.

## MEDIASTINAL GANGLIONEUROMA\*

ARTHUR G. JAMES, M.D., AND GEORGE M. CURTIS, M.D.

COLUMBUS, OHIO

FROM THE DEPARTMENT OF RESEARCH SURGERY, THE OHIO STATE UNIVERSITY

GANGLIONEUROMATA form a specialized group of more differentiated tumors originating from the sympathetic nervous system. Consequently, they may, fundamentally, arise from primitive cells originating within the neural crest; or later from sympathetic ganglia, or even within the adrenal medulla. Thus they are related, on the one side, to the less differentiated and more malignant sympatheticoblastoma or neuroblastoma, and, on the other, to the pheochromocytoma. Examples of the latter group occur clinically, as certain carotid body tumors or as the "carcinoid of the appendix."

While these well-differentiated tumors, originating from nervous tissue, may occur throughout the body, the majority are particularly found along the course of the major chain of sympathetic ganglia. Thus they commonly occur in the neck, thorax, abdomen and pelvis. Others appear within the cranium or along the course of certain of the cranial nerves. The majority appear to be tumors with a low tendency toward malignancy. In some respects, they may even resemble fibrosarcomata.

Ganglioneuromata were doubtless seen, although not recognized, by Odier, as early as 1803. In his comprehensive work "Die Krankhaften Geschwülste," published in 1863, Virchow used the term "neuroma" to designate the component group. At that time he even separated nerve tumors into true and false neuromata. Loretz' paper, in 1870, "Ein Fall von gangliösem Neurom (Gangliom)," gave origin to the present term, and presented the first authentic case report. Loretz concluded that the tumor he was differentiating arose from a prevertebral sympathetic ganglion within the mediastinum.

The wide distribution as well as the differentiation of ganglioneuromata gradually became known. In 1891, Marchand, investigating a tumor removed from the adrenal gland, concluded that structurally it closely resembled embryonic sympathetic nervous tissue. Wright, in 1910, further developed our present concept of these, as well as other tumors arising from the sympathetic nervous system. He separated them from sarcomata, carcinomata and lymphosarcomata, with which they had previously been confused. Wahl's valuable paper, in 1914, presents a splendid summary of the knowledge current at that time.

Subsequent to Loretz' original report, ganglioneuromata of the mediastinum were but occasionally recognized and recorded. About 15 were reported previous to 1932, with two-thirds of these appearing after 1923.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

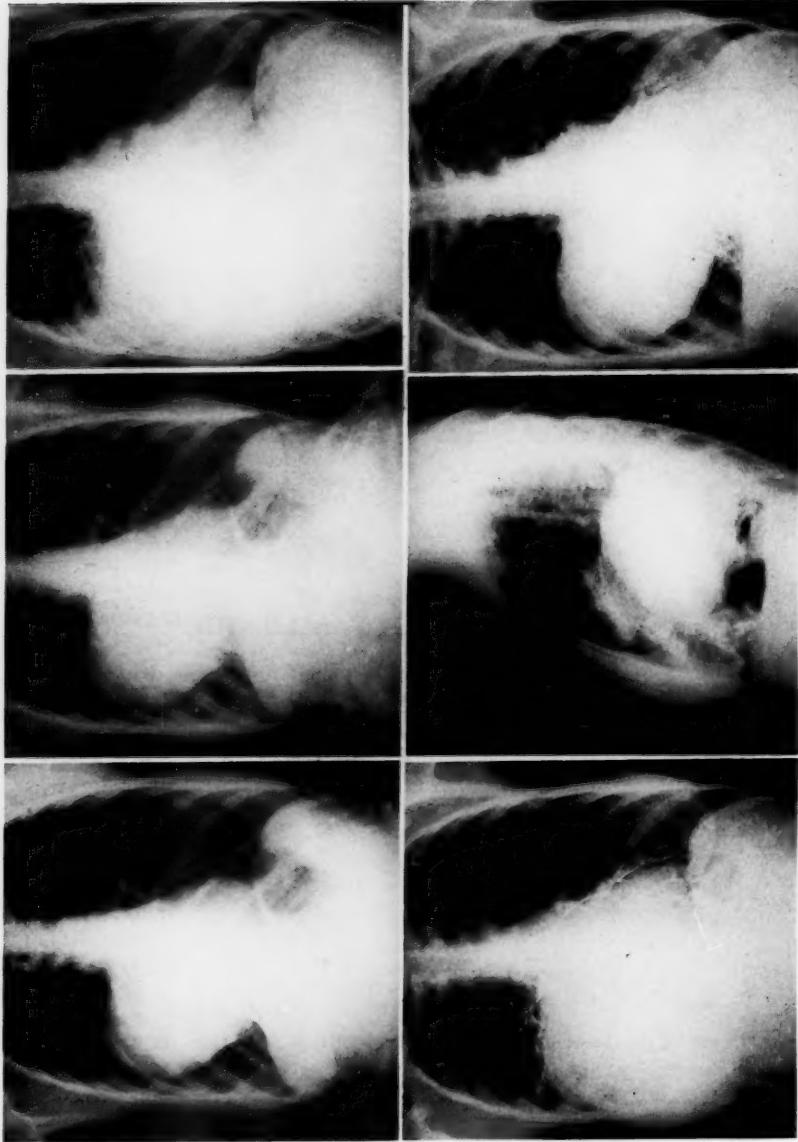
FIG. 1.  
FIG. 2.  
FIG. 3.

FIG. 1.—Discovery of the tumor, August 20, 1931, by a routine chest roentgenogram. Note the reflection of the pleura.  
 FIG. 2.—Three months later, November 10, 1931, there was no perceptible change. Note the lack of cardiac displacement.  
 FIG. 3.—Basal pleural effusion, January 26, 1939, with some dyspnea.  
 FIG. 4.—Iodoiodization, April 5, 1939, revealed an anteriorly lying lower right lobe.  
 FIG. 5.—Lateral view of tumor, April 6, 1940, outlined by pneumothorax.  
 FIG. 6.—Further pneumothorax completely collapsed the lung, and sharply delineates the tumor. The mediastinum remains fixed.

## MEDIASTINAL GANGLIONEUROMA

In 1929, Riggs and Good listed 65 recorded ganglioneuromata, but six of which had arisen within the thorax. In 1934, Bohrer and Lincoln again called attention to the infrequency of this form of mediastinal tumor.

With the recent development of thoracic surgery, this small list is definitely increasing. This is particularly due to the facility with which these tumors may be recognized roentgenologically, and removed by thoracotomy. In July, 1939, Allison and Carmichael were able to collect 19 cases. Their own case report, of an instance in which a mediastinal ganglioneuroma was successfully removed, reveals that it originated from the upper thoracic sympathetic chain.

Some uncertainty of classification yet remains. This concerns largely the interpretation of the varying degrees of differentiation observed, and especially as related to malignancy. However, while the tumor is admittedly rare, we have been able to collect more than 33 instances of what may reasonably be regarded as mediastinal ganglioneuromata. A chronologic bibliography of this series is presented.

To this latter group we are adding another that developed in the posterior mediastinum of the lower right chest of a young woman, age 35. This had grown to a size sufficiently large to cause respiratory embarrassment by the production of hydrothorax. As a consequence it was successfully removed by thoracotomy.

**Case Report.**—Hosp. No. 392148: R. K., a registered nurse, age 35, was referred to the Chest Clinic by Dr. David A. Tucker, of Cincinnati. She entered the University Hospital, April 4, 1939, complaining chiefly of dyspnea. The pertinent history dated back eight years, to 1931, at which time she entered nurses' training. Chest roentgenograms taken during her preliminary physical examinations revealed a tumor of considerable size in her right lower chest (Fig. 1). Moreover, when subsequently studied, this did not appear to be growing (Fig. 2).

She continued with her training and remained essentially symptom-free until about three and one-half months before admission, when she noticed an increasing dyspnea. During the course of the next two weeks, the respiratory difficulty became severe enough to incapacitate her. She also became conscious of palpitation. A roentgenogram, January 26, 1939 (Fig. 3), revealed considerable fluid in the lower half of the right chest, obscuring the tumor. Thoracentesis elsewhere, on three occasions had revealed considerable straw-colored fluid. Microscopic examinations of the sediment of the aspirated fluid did not reveal any malignant cells. She was subsequently given a series of 15 roentgen ray treatments, without obvious benefit. She noticed at times a nonproductive cough. There had been no weight loss. Her past and family history were noncontributory.

*Physical Examination* revealed a normal young woman, a little dyspneic on exertion. She had no fever, pulse 80, respirations 20, blood pressure 100/65.

The trachea was slightly deviated to the left. The chest appeared normal and revealed bilateral equal expansion. The left chest revealed a slight hyperresonance, and somewhat increased breath sounds. The lower right chest revealed flatness to percussion, and decreased to absent breath sounds and tactile fremitus posteriorly below the sixth rib. The anterior right chest also revealed dulness, as well as diminished breath sounds and tactile fremitus in its lower portion.

The vital capacity was 2,100 cc. Fluoroscopy showed the tumor to lie posteriorly. There was at that time a small amount of pleural transudate on the right side. The

tumor did not pulsate. The heart was not displaced, and the remainder of the chest was negative.

*Laboratory Data.*—The erythrocyte count was 4,560,000, with 13.5 Gm. of hemoglobin; the leukocyte count was 8,050 with 67 per cent segmenters, 2 per cent bands, 19 per cent lymphocytes, 10 per cent monocytes and 2 per cent eosinophil cells. The Wassermann and Kahn reactions were negative. Her basal metabolic rate was minus 17 per cent. Smears and cultures of the aspirated pleural fluid revealed no organisms.

Lipiodolization of the right lung was accomplished by the Singer method. This revealed a "puddling" in the right lower lobe bronchus at the point where the lower lobe was sharply compressed forward (Fig. 4). In fact, the right lower lobe was draped anteriorly over the tumor mass which also compressed upward the overlying lung (Fig. 5). Pneumothorax was commenced, both for its diagnostic value and as a preparation for the proposed widely open thoracotomy (Fig. 5). Thoracentesis again yielded 70 cc. of straw-colored fluid, which chemically and microscopically showed it to be an effusion. Pneumothorax was subsequently increased in stages until complete collapse of the right lung was obtained (Fig. 6).

On April 13, 1939, thoracotomy was performed and the tumor uneventfully removed before a visiting group from the Detroit Academy of Surgery. Under avertin and nitrous oxide anesthesia, with positive pressure available but found not necessary, an incision was made over the tenth rib posteriorly, and generous segments of the ninth and tenth ribs subperiosteally were resected. The pleura was opened through the periosteal bed of the ninth rib. This exposed a large grape-fruit-sized tumor, firmly attached along the lateral vertebral bodies in the region of the normal course of the lower thoracic sympathetic chain of ganglia. The pleura was obviously edematous and thickened, and the mediastinum well stabilized. In fact, after a brief safety period during which it became clear that the mediastinum was fixed, the operation was continued under ordinary anesthesia.

Adhesions between the lung and the upper, anterior pole of the tumor were first freed. The thickened pleura covering the tumor was then split and bluntly dissected away, leaving the uncovered tumor to project free into the pleural cavity. By blunt finger-dissection the tumor was then separated from the pericardium and the lower posterior mediastinal tissues. The adhesions were not dense and there was no infiltration. The tumor capsule was definite and shaggy. There finally remained a tough fibrous stalk attached along the lateral vertebral bodies, just posterior to the pericardium. The mediastinal pleura was then further separated, better exposing the attachment of the stalk and suggesting its intercostal blood supply. It was clamped, the tumor removed, and the stalk then ligated. The redundant mediastinal pleura was then plastically closed and anchored to the stalk stump. A mushroom catheter was then inserted through a posterior stab wound and the incision closed.

The preoperative blood pressure had been 90/60, and had fallen during the operation to 70/50. As a consequence, she was transfused immediately postoperatively. Upon return to her room, suction drainage was gradually instituted through the catheter and eventually maintained at 10 cm. of water pressure. The following day a portable roentgenogram showed the lung to be completely reexpanded.

Her temperature reached a height of 103° F. on the second day, and then gradually subsided to normal by the tenth postoperative day. A roentgenogram taken five days after operation showed but slight pleural reaction at the right base (Fig. 7). On the eleventh postoperative day, lipiodol was injected through the catheter at moderate pressure; however, no residual pocketing could be demonstrated. The catheter was consequently removed. She was allowed up on the twelfth day and discharged on the seventeenth day.

She returned to the Chest Clinic for check-up about two months later. At that time, she had no complaints; she had gained weight and noted no symptoms. The chest examination was negative. The vital capacity had increased 300 cc., and was 2,400 cc.

## MEDIASTINAL GANGLIONEUROMA

Stereoscopic roentgenograms still revealed some density at the right lower base. Repeated subsequent examinations have revealed no unfavorable sequelae.

On July 11, 1940, 15 months postoperative, her vital capacity had increased 600 cc.—to 2,700 cc. Throughout, there has been no evidence of malignancy. She has maintained her weight-gain and remains in excellent physical condition. Improvement is further shown by the roentgenogram taken that day (Fig. 8). She is carrying on her usual work.

FIG. 7.

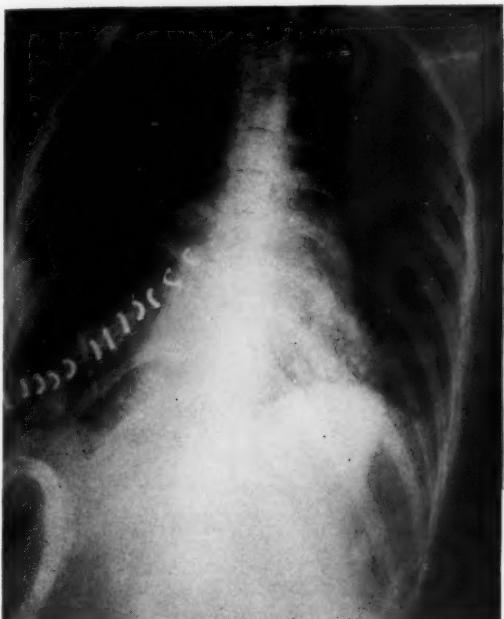


FIG. 8.

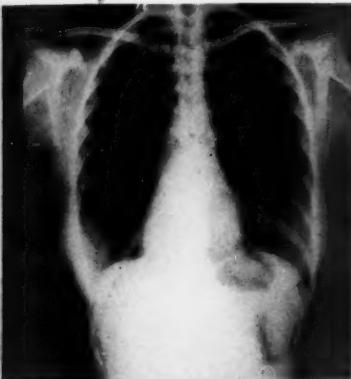


FIG. 7.—By means of catheter suction the lung has reexpanded, five days post-operative.

FIG. 8.—Fifteen months postoperative, July 11, 1940, there is little abnormal to be noted save the absence of ribs 9 and 10 posteriorly.

**Pathologic Examination.**—**Gross:** Upon sectioning the tumor soon after its removal (Fig. 9), the predominance of a soft matrix, which resembled myxomatous tissue, caused us originally to regard it as of mesodermal origin. And we are, consequently, greatly indebted to Dr. Harry L. Reinhart, pathologist to the University Hospital, whose investigation led to the recognition of its neurogenic nature. He has furnished us with the basis for the following description of the principal pathologic findings.

The tumor was a large, ovoid, encapsulated mass, measuring 13x10x9 cm., and presenting a rough fibrous area (Fig. 9 A) of attachment at the mediastinum. The remainder of the capsule was unbroken. The surface was shaggy, due to the separation of the overlying pleura. Two cysts were present, both containing hemorrhagic fluid. Three types of tissue were evident: (1) Extensive edematous to myxomatous appearing areas, interspersed by (2) areas of a more fibrous character, which were yellowish in color and arranged in an irregular lattice network; and (3) areas of hemorrhage. The capsule was not invaded.

**Microscopic.**—Examination revealed a predominance of loose, edematous fibrillar stroma, presenting but few cells (Fig. 10). Scattered irregularly and sparsely throughout this stroma are found nests of cells (Fig. 11) whose nuclei differ from the oval to pyknotic nuclei of the stroma. These cells are, in certain areas, closely related to a more dense fibrillar stroma (Fig. 12). When differentiated by trichrome stain and examined under high power they present a series, beginning with round nuclei and a

moderate amount of cytoplasm, suggestive of plasma cells, and ending with sympathoblasts and an occasional multipolar sympathetic ganglion cell (Fig. 13). The cellular development within these groups is, to a considerable extent, at the sympathoblastic and neuroblastic stage of differentiation. Mitotic figures are very scarce; however, cells containing from two to four nuclei are common. Cellular degeneration is prominent even in these cell groups, and varies from cytoplasmic vacuolization and nuclear pyknosis to focal areas of granular detritus where apparently entire nests of cells have undergone degeneration. This picture is so pronounced that, were it not for the large amount of fibrillar material remaining, the proliferative and neoplastic character of the growth might be easily overlooked.

The character of the cells and the production of large amounts of fibrillar tissue together with the disappearance, to a large degree, of the cells responsible for the production of such material, stamp the tumor as a ganglioneuroma.

In the light of the inherent biologic character of ganglioneuromata these features warrant the assumption that the tumor has been slowly progressive over a period of several years, while the encapsulation and low rate of cellular proliferation suggest a relatively benign histologic character. McFarland and Sappington presented an excellent study of the more detailed histologic features of ganglioneuromata, most of which are duplicated in this tumor.

**DISCUSSION.**—The anlage of the sympathetic nervous system appears relatively early in the embryo, as cells of the neural crest. According to Kuntz, the sympathetic primordium consists of cells which migrate outward in varying degree from the neural crests. These cells have been designated sympathogonia. They develop into slightly larger cells with more vesicular nuclei—the sympathoblasts. These cells are pluripotential and may, according to Bailey, give rise to (a) neuroblasts—from which the ganglion cells of the sympathetic nervous system develop; (b) pheochromocytes of the adrenal system; or (c) astroblasts—glial cells of the sympathetic system which ripen into astrocytes.

A classification of tumors arising from these cells and showing the relations and position of ganglioneuroma, as presented by Scott and Palmer, is as follows:

- (I) Completely undifferentiated—Sympatheticoblastoma:
  - (1) Tumors composed of migratory cells and sympathogonia.
  - (2) Sympathoblastoma.
- (II) Incompletely differentiated:
  - (1) Sympathetic neuroblastoma.
  - (2) Pheochromoblastoma.
  - (3) Astroblastoma.
- (III) Completely differentiated:
  - (1) Ganglioneuroma.
  - (2) Pheochromocytoma.
  - (3) Astrocytoma.

The neuroblastoma is the most common type found in children and arises frequently in the suprarenals. The true ganglioneuroma is rare in children. It is considered benign when found early in its development. Formative cells

## MEDIASTINAL GANGLIONEUROMA

are not present. Adult ganglion cells have been found in the adjacent lymph nodes in a few instances and have been described as metastatic. It has been demonstrated that typical ganglioneuromatous elements may occur in malignant metastasizing tumors. Cushing and Wolbach reported an instance in which the tumor reverted from a malignant sympathoblastoma to a benign ganglioneuroma.

FIG. 9.



FIG. 10.

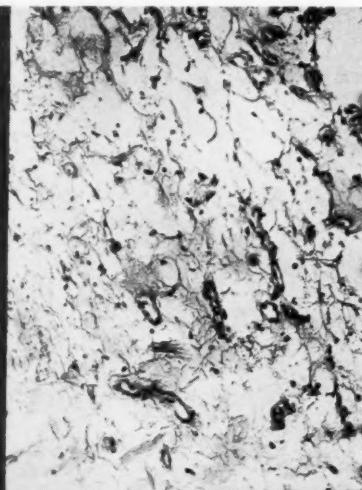


FIG. 11.

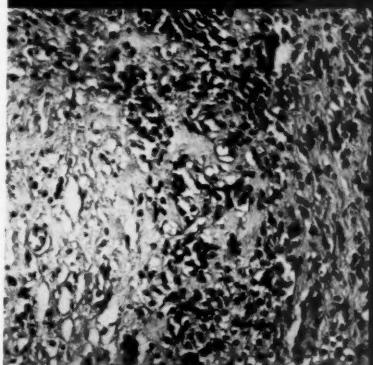


FIG. 12.

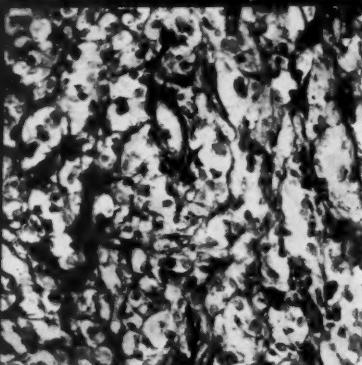


FIG. 9.—Median section through the tumor. Note the smooth capsule, the attachment at A, and the three types of tissue.

FIG. 10.—The loose myxomatous fibrillar stroma which predominated throughout the tumor.

FIG. 11.—Presents nests of nerve cells within a loose stroma. (Trichrome stain— $\times 240$ .) Note the vascularity of the tumor.

FIG. 12.—The relation of cells to fibrils in a more cellular area of coarsely fibrillar stroma. (Trichrome stain— $\times 570$ .)

Bigler and Hoyne reviewed a group of 97 cases of ganglioneuroma, collected up to 1931. They found that the more benign the tumor the more advanced was the age incidence. Forty-one cases occurred in children, and 43 in adults. The youngest patient was a new-born infant, the oldest was

age 73. The sex was given in 79 cases. Of these, 46 were females, and 33 were males. Distribution was given in 90 cases, as follows:

Brain.....	15
Cranial nerves in head.....	7
Neck.....	11
Mediastinum.....	11
Retroperitoneally, and in pelvis.....	46

Where the side of the body was given, 29 occurred on the left, and 22 on the right. Thirty-nine cases were operated upon. Thirty-four of these recovered, and five died.

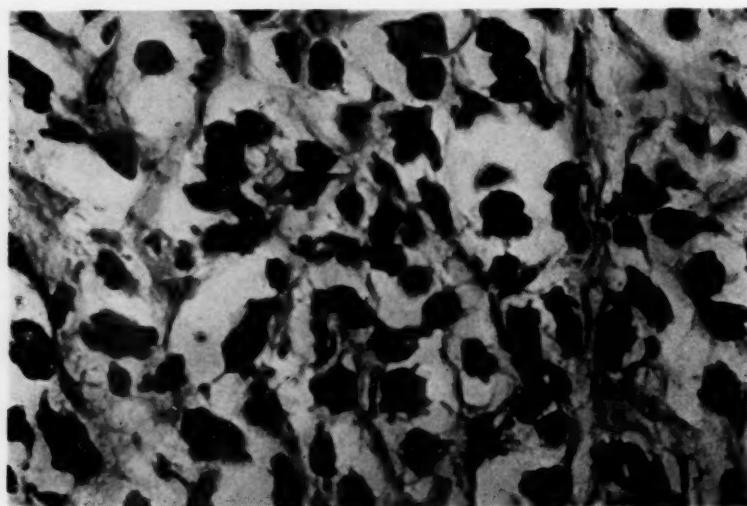


FIG. 13.—Various stages of cellular differentiation including multipolar ganglion cells.  
(Trichrome stain— $\times 800$ .)

Even though embryonic elements were found to be present, removal of the tumor led to recovery without recurrence of the growth or the development of subsequent metastases. In operable cases, therefore, the prognosis would appear to be good even though evidence of undifferentiated cells later appears during microscopic study. The only suitable treatment appears to be surgical removal. Roentgenotherapy has been tried, without apparent beneficial result, as in our case. There is no evidence that the tumors decrease in size spontaneously.

#### SUMMARY

Mediastinal ganglioneuroma is a rare tumor although more will doubtless be discovered with the rapid progress of thoracic surgery. About 20 instances were collected prior to this report. We have been able to assemble more than 33 cases from the available literature. These are chronologically presented. The tumor consists of nerve cells embedded in a large amount of fibrillar stroma. It presents a low tendency toward malignancy, which varies inversely with the age of the patient. The only beneficial treatment appears to

## MEDIASTINAL GANGLIONEUROMA

be surgical removal. Roentgenotherapy is of no apparent benefit. The prognosis is good in operable cases, and depends to some extent upon the degree of differentiation.

A case is presented in which a large ganglioneuroma was successfully removed from a young woman, age 35, with recovery. After 20 months, there is no evidence of recurrence.

### A CHRONOLOGIC BIBLIOGRAPHY PERTAINING TO MEDIASTINAL GANGLIONEUROMA

- <sup>1</sup> Loretz, W.: Ein Fall von gangliösem Neurom (Gangliom). *Virchows Arch. f. path. Anat.*, **49**, 435, 1870.
- <sup>2</sup> Borst, M.: Die Lehre von den Geschwülsten. Wiesbaden, J. F. Bergman, 1902, p. 241.
- <sup>3</sup> von Rindfleisch: Case cited by Borst,<sup>2</sup> p. 242.
- <sup>4</sup> Tschistowitsch Russk. Uratsch, 1908; Abstr. in den Deutsch. Medizinaltg. No. 18, **31**, 319, 1910.
- <sup>5</sup> Friedrich, J.: Ein Fall von Ganglioneurom des Sympathikus. *Frankfurt Ztschr. f. Path.*, **10**, 456, 1912.
- <sup>6</sup> Rosenson, W.: Neoplasms of Mediastinum in Infancy and Childhood. *Am. Jour. Dis. Child.*, **26**, 411, 1923.
- <sup>7</sup> Sauerbruch, F.: Necrosis of Lung Following Extirpation of Ganglioneuroma. *Münch. med. Wchnschr.*, **70**, 1011, August 3, 1923; Abstr. *J.A.M.A.*, **81**, 1400, October 20, 1923.
- <sup>8</sup> Stout, A. P.: Ganglioneuroma of Cervical and Thoracic Sympathetic Ganglia. *J.A.M.A.*, **82**, 1770, May 31, 1924.
- <sup>9</sup> Brunner, A.: Removal of Ganglioneuroma of Posterior Mediastinum. *Arch. f. klin. Chir.*, **129**, 364, 1924.
- <sup>10</sup> Riggs, T. F., and Good, L. P.: Ganglioneuroma of Mediastinum Requiring Surgical Intervention for Relief of Obstructive Symptoms. *Arch. Surg.*, **19**, 309, 1929.
- <sup>11</sup> Harvey, W. G.: Ganglioneuroma of Mediastinum in a Child, Aged 9. *Lancet*, **1**, 405, February 22, 1930.
- <sup>12</sup> Lazarovits, L.: Ganglioneuroma of Posterior Mediastinum. *Gyógyászat.*, **70**, 327, April 27, 1930.
- <sup>13</sup> Jackson, C., and Babcock, W. W.: Intrathoracic Ganglioneuroma. *South. Clin. North America*, **11**, 1231, December, 1931.
- <sup>14</sup> Beretervide, J. J., Fazio, J. M., and Cardenau, J. B.: Ganglioneuroma of Mediastinum. *Rev. Soc. de Méd. Int. y Soc. de Tisiol.*, **7**, 71, March-May, 1931; also *Prensa Méd. Argent.*, **18**, 41, June 10, 1931.
- <sup>15</sup> Ranzi, E.: Ganglioneuroma of Mediastinum. *Wien. klin. Wchnschr.*, **44**, 840, June 26, 1931.
- <sup>16</sup> Griesbach, R.: Intrathoracic Ganglioneuroma. *Ztschr. f. Tuberk.*, **65**, 365, 1932.
- <sup>17</sup> Bigler, J. A., and Hoyne, A.: Ganglioneuroma. *Amer. Jour. Dis. Child.*, **43**, 1552, 1932.
- <sup>18</sup> Armand-Delille, P., Lestocquoy, C., and Garois, H.: Intrathoracic Ganglioneuroma of Sympathetic Origin. *Bull. Soc. de Pédiat. de Paris*, **30**, 474, October, 1932.
- <sup>19</sup> Bohrer, J. V., and Lincoln, E. M.: Ganglioneuroma of Chest in Children. *Jour. Thoracic Surg.*, **3**, 365, April, 1934.
- <sup>20</sup> Sophian, L.: Mediastinal Ganglioneuroma. *ANNALS OF SURGERY*, **101**, 837, March, 1935.
- <sup>21</sup> Distefano, G.: Endothoracic Ganglioneuroma. *Tumori*, **9**, 245, 1935.
- <sup>22</sup> Calzolari, T.: Ganglioneuroma of Mediastinum; Four Cases. *Ann. ital. di chir.*, **14**, 15, January, 1935.
- <sup>23</sup> Žahourek, V.: Roentgen Diagnosis of Intrathoracic Neurogenic Tumors in Connection with a Case of Mediastinal Ganglioneuroma. *Časop. lék. Česk.*, **75**, 589, May 1, 1936.
- <sup>24</sup> Dobraniecki, W., and Stankiewicz, S.: Sympathetic Origin of Ganglioneuroma of Neck and Anterior Mediastinum. *Jour. de Chir.*, **48**, 785, December, 1936.

- <sup>25</sup> Lanari, E. L., Pardal, R., and Aquirre, J. A.: Intrathoracic Ganglioneuroma. *Prensa Méd. Argent.*, **24**, 2001, October 20, 1937.
- <sup>26</sup> Aiker, A.: Unusual Endothoracic Tumor (Ganglioneuroma of Sympathetic). *Röntgen Praxis*, **10**, 95, February, 1938.
- <sup>27</sup> Magalhaes, A. A.: Intrathoracic Ganglioneuroma. *Arch. Argent. de Pediat.*, **9**, 275, September, 1938.
- <sup>28</sup> Clarke, J. M.: Large Thoracic Ganglioneuroma. *Australian and New Zealand Jour. Surg.*, **8**, 199, October, 1938.
- <sup>29</sup> Cabot, R. C.: Ganglioneuroma. *New England Jour. Med.*, **219**, 620, October 20, 1938.
- <sup>30</sup> Allison, P. R., and Carmichael, R.: Mediastinal Ganglioneuroma. *Brit. Jour. Surg.*, **27**, 175, July, 1939.
- <sup>31</sup> Cooley, L. E., and McNamara, F. P.: Intrathoracic Ganglioneuroma, *Jour. Iowa Med. Soc.*, **30**, 117, March, 1940.
- <sup>32</sup> Scott, E., and Palmer, D. M.: Intrathoracic Sympatheticoblastomas. *Am. Jour. Cancer*, **16**, 903, 1932.
- <sup>33</sup> Odier: Cited by Wahl, H. R.<sup>42</sup>: Neuroblastomata. *Jour. Med. Res.*, **30**, 205, 1914.
- <sup>34</sup> Virchow, R.: *Die Krankhaften Geschwülste*. Berlin, A. Hirschwald, 1863, Vol. 3.
- <sup>35</sup> Marchand, F.: Beiträge zur Kenntnis der Glandula Carotica und der Nebennieren. *Internat. Beitr. z. Wissenschaftl. Med., Festschr. f. R. Virchow*, **1**, 578, 1891.
- <sup>36</sup> Wright, J. H.: Neurocytoma or Neuroblastoma: A Kind of Tumor Not Generally Recognized. *Jour. Exper. Med.*, **12**, 556, 1910.
- <sup>37</sup> Kuntz, A.: *Anatomic Nervous System*. Philadelphia, Lea and Febiger, 1929.
- <sup>38</sup> Bailey, P., and Cushing, H.: A Classification of Tumors of the Glioma Group. Philadelphia, J. B. Lippincott, 1926.
- <sup>39</sup> Cushing, H., and Wolbach, S. B.: Transformation of a Malignant Paravertebral Sympatheticoblastoma into a Benign Ganglioneuroma. *Am. Jour. Path.*, **3**, 203, 1927.
- <sup>40</sup> McFarland, J., and Sappington, S. W.: A Ganglioneuroma in the Neck of a Child. *Am. Jour. Path.*, **11**, 429, 1935.
- <sup>41</sup> Foot, N. C.: Histology of Tumors of the Peripheral Nerves. *Arch. Path.*, **30**, 772, September, 1940.
- <sup>42</sup> Wahl, H. R.: Neuroblastomata. *Jour. Med. Res.*, **30**, 205, 1914.

DISCUSSION.—DR. JULIAN MOORE (Asheville, N. C.): Doctor Curtis has reported the successful removal of a ganglioneuroma from the mediastinum, and I think he and his patient are to be congratulated. I think it well to extend the discussion to all intrathoracic tumors. They are more frequent than is indicated in the literature, and while some are not amenable to removal, many are benign and can be removed. There is still confirmed pessimism among medical men about removal. Several years ago, I saw a patient who had been advised against having the tumor removed because it was doing no harm. The benign extrapulmonary tumor may embarrass the function of the heart, lungs or mediastinal structures. All are potentially malignant. They should be removed when first seen, provided there is no valid contraindication. When they grow to such size as to embarrass respiration or circulation, the chance of successful removal is diminished.

I would like to call attention to a few points in the question of diagnosis. Roentgenograms are helpful. Diagnostic pneumothorax will show whether the tumor is extrapulmonary or intrapulmonary. Bronchoscopy is helpful, only, in eliminating tumor of the large bronchi. In differentiating whether it is benign or malignant, a therapeutic test of roentgenotherapy is certainly helpful.

With regard to operation, I personally prefer to use cyclopropane or "closed ether" in preference to nitrous oxide-oxygen. In performing such operations with nitrous oxide and oxygen I have a feeling that I am run-

## MEDIASTINAL GANGLIONEUROMA

ning a race with anoxemia. With cyclopropane or "closed ether" anesthesia your patient does not suffer from anoxemia and you can take your time. One must use pressure anesthesia, but it is not necessary to use intratracheal, unless there is obstruction or unless there is a large amount of pus and secretion which must be aspirated.

I reported a case several years ago, and that patient is alive and well after ten years. The first one I saw operated upon was when I was at Ann Arbor. This patient had a ganglioneuroma, which was removed, and the patient died of mediastinal emphysema. A number of men advocate closing the wound tightly, but I always insert a catheter and apply suction for 24 or 48 hours, which I think guards against mediastinal emphysema and tension pneumothorax. It probably does increase the risk of infection, but I cannot forget the former experience, and the suction has proved very satisfactory in my hands.

## ENDOCRINE STUDIES OF PATIENTS AFTER SUBTOTAL HYPOPHYSECTOMY\*

PAUL STARR, M.D., AND LOYAL DAVIS, M.D.

CHICAGO, ILL.

FROM THE DIVISIONS OF MEDICINE AND SURGERY OF NORTHWESTERN UNIVERSITY MEDICAL SCHOOL, CHICAGO, ILL.

A SYSTEMATIC STUDY of endocrine function in patients who have had subtotal hypophysecomies has been made with the intention of directing substitution therapy in the larger group of patients who have had nonfunctioning tumors of the hypophysis, and of determining the necessity for further depressant therapy in those having hyperfunctioning pituitary adenomata. This was suggested by experience with patients after subtotal thyroidectomy, in whom a state of hypothyroidism, of hypoparathyroidism, or rarely, persistent hyperthyroidism required continued supervision and treatment.

Disability in such patients may be due to (1) failing vision, the usual indication for operation; (2) cerebral damage in important neighboring hypothalamic areas; or (3) endocrine deficiency or excess. The symptoms of endocrine dysfunction, present before the operation, may continue post-operatively but should be susceptible of correction. However, an important condition modifies the results of endocrine therapy. If the pituitary deficiency is so pronounced that its tropic influence on the subsidiary glands is entirely lacking, the injection of pituitary extract is ineffective. On the contrary when less serious pituitary deficiency exists, as in mild Fröhlich's disease, the injection of pituitary extract may develop the target organ, make it more sensitive to pituitary hormones, and thus it is more effective. In many cases the postoperative pituitary remnant is not able to supply sufficient hormone to maintain the secondary gland. Furthermore, the deficiency has often been present for years and the atrophy of the receptive organ may be so great that it does not respond to extract injections. Hence it would seem that the object of endocrine therapy, in these cases, should be to supply the hormones of the glands which the pituitary normally maintains; that is, the thyroid, the adrenal, and the gonad.

In addition to the usual complete clinical examination the following plan of study was carried out: (1) The basal metabolic rate was determined. It has been found in animals that total hypophysecomy of the normal animal leads to a metabolic rate 25 per cent less than average normal. In addition, if thyroid atrophy occurs, the metabolic level will fall to that of athyreosis. (2) The blood cholesterol was also determined. Hypopituitarism is characterized by normal or subnormal levels, but if hypothyroidism is superimposed the blood cholesterol will rise. (3) The condition of the adrenal

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## SUBTOTAL HYPOPHYSECTOMY

cortical function in our patients was determined by the Wilder test because the adrenal cortex is maintained by the tropic action of a pituitary factor. For this test, the ingestion of sodium is reduced in the diet to a known low level and the potassium is raised by foods selected; the addition of potassium citrate over a period of two days and four hours, and the water intake, is prescribed according to the patient's weight. Under these conditions the normal adrenal cortical function will restrict the loss of sodium and chloride in the urine, but in adrenal deficiency the sodium and chloride concentration of the urine in the last period of the test becomes elevated. Comparison of many other substances in the blood and urine indicates that among all these the concentration of chloride in the urine, in the four hours after the two days' dietary preparation, is the most significant for the establishment of adrenal cortical function. This test, of course, demonstrates only the electrolytic controlling function of the adrenal glands and does not determine, directly, the carbohydrate controlling function. The normal values found for the chloride concentration of the urine in the terminal four-hour sample fall below 125 mg. per 100 cc. of urine; values between 125 and 225 mg. may occur in normal persons or in those having adrenal insufficiency; values above 225 of chloride ion in milligrams per cent occur only in patients with adrenal cortical insufficiency. The sodium loss is adequately represented by the chloride determination. This test, then, is an extremely simple and valuable one, which requires only dietary control for 52 hours and a chloride titration in the urine. Except for the time involved, it is the simplest of all the endocrine assay tests. Its introduction now allows us to determine the function of one of the major glands that has hitherto been neglected in much endocrine analysis.

(4) Carbohydrate balance, involving as it does the diabetogenic function of the pituitary, the responsiveness of the adrenal cortex to that hormone, the state of the liver as influenced by the thyroid, and the activity of the insulin-producing organ, was studied as usual by the glucose tolerance and insulin tolerance tests. One hundred grams of glucose was the test dose in the former, with capillary blood-sugar determinations made before, and one-half, one, two and three hours after ingestion of the sugar. Ten units of plain insulin were given in the latter, with similarly distributed blood-sugar determinations.

(5) The gonadotropic function of the pituitary was estimated by the history of amenorrhea and loss of sexual activity, combined with the physical examination of the sexual organs to determine the degree of atrophy. In some cases the vaginal epithelium was studied for evidence of estrogenic activity according to the morphology of the cells and their straining characteristics, after the method of Papanicalao. (6) Parathyroid function was observed by determination of the blood calcium and phosphate and a study of bone roentgenograms. In one case, hyperparathyroidism was discovered and titration of urinary calcium was carried out.

As is usual in such a series, the number of patients with hypopituitarism

was three-fourths of the whole number, in this instance, 18 of 25. In all instances, these patients had hypopituitarism before operation, occasionally with cerebral damage accompanying the visual disturbance. The hypopituitarism continued after operation; the nervous disorder was in some instances improved but in other instances increased; the visual loss was usually arrested or relieved, but several patients developed blindness some years after operation.

These 18 patients may be divided into three groups: First, those with severe hypopituitarism, with resultant total disability, with more or less cerebral damage, and loss of visual acuity; second, those with endocrine deficiency and moderate disability; and third, a group with slight endocrine deficiency and relatively little incapacity. There are seven patients in the first group, four in the second, and seven in the third. The case history of a patient illustrating the first group is as follows:

**Case 1.**—G. D., male, age 60 in 1940. At the age of 44, progressive loss of vision began, affecting the left eye more than the right; sudden, unexplained obesity, loss of body hair, loss of libido, and extreme drowsiness developed. He was given four roentgen ray treatments at another clinic, with arrest of the process for five years. Loss of vision in the right eye then began, and surgical removal of the tumor was advised. Until the onset of this disease at age 44, he had been in normal health. He has two grown sons.

At the time of operation, when the patient was 51 years of age, he was tall and slender. He had a very scanty, soft beard which required shaving only twice a week. There was absence of hair on the chest, axillae, arms and legs and pubis, and he was wholly devoid of eyebrows. The left eye was completely blind. There was a small visual field in the nasal half of the right eye. Both optic nerves were extremely pale and showed a very definite primary optic atrophy. The sella turcica was very large, and ballooned out. The posterior clinoid processes were so thin that they were represented by fine shadows.

At operation, a purplish, bulging mass, which occupied the sella and extended forward beneath the chiasm between the optic nerves, was found. The contents of the mass were removed and, on microscopic examination, proved to be a pituitary chromophobe adenoma. His chief complaint at the time of discharge from the hospital, December, 1931, was impairment of vision. This, however, soon began to improve. He was unsteady in gait and became quickly exhausted; occasionally, he was troubled with episodes of nausea. His condition remained unchanged until October, 1938, when a cerebral accident occurred which resulted in a right hemiparesis, loss of sphincter control, and hyperthermia. He survived this but was bed-ridden until his death in March, 1940.

An endocrine study, in 1939, indicated hypometabolism, with a basal metabolic rate of -23 per cent, but relative thyroid sufficiency in proportion to the lowered demand of the general severe hypopituitary state, since the blood cholesterol was normal—202 mg. per 100 cc. of blood. The adrenal condition was one of deficiency, as indicated by muscular weakness and a blood pressure of 108/80. Three Wilder tests were elevated, giving final chloride concentrations of 280, 410 and 190 mg. per cent of urine. Carbohydrate metabolism was sluggish. The sugar tolerance could not be made because of vomiting, but a similar patient (Mr. C. E.) had a sugar tolerance as follows: Fasting blood sugar, 75; one-half hour after 100 Gm. of glucose by mouth, blood sugar, 104; after one hour, 80; after two hours, 116; after three hours, 105—showing an absence of alimentary hyperglycemia. The insulin tolerance, as is usual in such cases, indicated marked sensitivity to insulin, with a fasting blood sugar of 106 which, upon the administration of ten units of plain insulin, dropped to 42 mg. per 100 cc. of blood in two hours. The

## SUBTOTAL HYPOPHYSECTOMY

gonadotropic function of the pituitary was absent as indicated by absence of sexual urge, absence of hair, and atrophic primary and secondary gonads.

A second patient of the same type, operated upon November 25, 1938, further illustrates this first group.

**Case 2.**—Until 27 years of age this patient (Mr. L. H.) was an active, alert clerk in a hardware store. He was married and had two children. In the summer of 1930, a box of hardware fell on his head as he was pulling another box out from under it. The blow dazed him momentarily but did not knock him down or cause any laceration. After this incident he began to feel weak and to have difficulty in remembering the whereabouts of articles in the store. Loss of libido and impotence were noted during the next year. Two years later, that is, at age 30, he was under treatment by a reputable physician for six months because of weakness and colonic irrigations, and iron and arsenic were given without benefit. At age 31, he was a patient at an excellent hospital where treatment for anemia was given. While in the hospital, he began to suffer from headaches which were frontal and diffuse, accentuated by severe spasms of pain lasting a few seconds. At age 31, loss of beard growth, and loss of hair on the chest and arms began, and at the time of operation he had no hair in these areas, whereas at one time he had a thick growth. At this same age, failing vision occurred and, finally, the true nature of his difficulty was recognized. Roentgenotherapy was administered over a two-year period, with only temporary relief. At age 35, he entered the hospital complaining of weakness, fatigue, lethargy; loss of sexual urge and potency; loss of facial and body hair; unexplained obesity; variable headaches; loss of vision; polyuria and polydipsia.

Roentgenograms showed a large, distorted sella, with a shadow of suprasellar calcification. A cystic craniopharyngioma was found at operation, and this was evacuated. Postoperative recovery was good; vision was retained and the headaches relieved. Very rare sexual activity occurred after an absence of eight years, but somnolence and marked weakness continued. Approximately one year after operation (1939) evidences of cerebral pathology became manifest; convulsions and hemiparesis have occurred and, at present, the patient is completely disabled.

Endocrine study showed extreme glandular deficiency; the basal metabolic rate was —40 per cent, the blood cholesterol 392, the Wilder test 380; the sugar-tolerance test curve was flat; insulin sensitivity marked; libido was very slight; and the testicles and prostate were atrophic. Hence, deficiency of thyrotropic, adrenotropic, and gonadotropic hormones was indicated. In this patient, the large cystic craniopharyngioma had evidently damaged the adjacent brain structures irreparably and destroyed the pituitary gland by pressure.

The remaining patients in this and succeeding groups are much less discouraging because injury to the brain was less severe and endocrine deficiency less extreme. There is, however, a group of patients partially disabled. This type may be illustrated by the case of Miss M. H.

**Case 3.**—This patient entered the hospital at age 53. She had had a premature spontaneous menopause at age 28. At age 43, a period of headaches and pain in the right eye had occurred. A diagnosis of hypothyroidism was made, although, doubtless, pituitary disease could have been diagnosed at that time. These symptoms subsided. On admission to the hospital, two years later (1934), she complained of failing vision for two months; somnolence; unsteady gait and unceinate fits. A left homonymous hemianopsia was present.

Roentgenograms showed an enormous sella turcica. At operation, the right optic nerve was found to be tightly stretched over a purple tumor mass that lay between the two nerves and beneath the chiasma. The capsule was opened and adenomatous tissue removed by curet until the tumor collapsed. Recovery was uneventful—with enlarge-

ment of the visual fields. The patient did not return to her former occupation because she did not feel strong enough. She has been very much inclined to forget things and has been unable to recall events that happened prior to the operation.

At the time of our endocrine study, five years after operation (1939), she presented the picture of moderate obesity, in a pleasant, cooperative woman, age 58. She carried on a normal but limited home life. The blood pressure was 148/78, pulse 68, temperature normal. The hair was normal and the skin smooth. The eyes reacted to light and accommodation. The thyroid was palpable but not nodular. Pelvic examination showed slight atrophy of the vaginal epithelium and a small uterus.

Endocrine studies indicated hypometabolism—a basal metabolic rate of —18 per cent and blood cholesterol of 324 demonstrated hypothyroidism. The Wilder test was normal (70 mg. per cent); the sugar tolerance test was low; there was marked sensitivity to insulin; the blood sugar dropped from 78 to 43 in one hour, and signs of hypoglycemic shock occurred. Gonadotropic function was absent. She has been benefited by small doses of thyroid.

As an example of a still more favorable course, the case of Mr. H. E. may be presented.

**Case 4.**—The patient is now age 52, and is a salesman in a department store, actively at work. He is married and has two children; the younger was born when he was age 34. The following year, while playing tennis, he suddenly discovered that his left eye was totally blind; this persisted for two or three days, after which the blindness was confined to the temporal field of the left eye. This condition remained without notable change until he was age 38. Sexual impotency began approximately at the same time as the amblyopia. At age 38, he experienced severe, constant headache for a period of about ten days; he then noticed that he was unable to see traffic lights or to read any part of a newspaper other than the headlines. He consulted an "eye doctor" who prescribed rest for the eyes for a few days. From then, until age 45, he read only with the help of a magnifying glass. Late in his forty-fourth year he consulted a doctor in Chicago about his eyes, was told that he had syphilis, and was given a course of neoarsphenamine. After some treatment he had arsenical poisoning; his hair fell out, he had a high temperature, and his skin desquamated. Meanwhile the sight in both eyes became steadily worse. Finally, he had a series of severe headaches which continued for two weeks until one morning he awoke completely blind.

Röntgenograms showed marked distention of the sella, with erosion of the posterior clinoid processes and floor. Visual fields showed blindness of the left eye and a small nasal field of vision in the right eye.

At operation (1933), the right optic nerve was found to be tightly stretched and thinned-out over the surface of a large, purple, dome-shaped tumor mass in front of the chiasm. The contents of the tumor were a dark chocolate-brown fluid and a small amount of soft degenerated adenomatous tissue. This was removed completely, so that the chiasm and nerves hung loosely in the field. The tumor was a chromophobe adenoma which had had hemorrhage into it or had undergone degeneration. The patient made a good postoperative recovery, and has been working ever since—a period of seven years. Vision has not returned to the left eye, but the nasal field of the right eye is maintained.

Endocrine study, six years after operation (1939), gave the following results: Basal metabolism was within normal range (—14 per cent). There was evidence of slight hypothyroidism, that is, the blood cholesterol was 282 (normal upper limit 240 mg. per cent). An interesting finding, on a single determination, was a very high Wilder test —568 mg. per 100 cc. of urine; this did not fit in with his clinical condition, although his blood pressure was low normal (108/78). Sugar tolerance was normal and insulin sensitivity was absent. Gonad atrophy and absence of activity indicated lack of gonadotropic function.

## SUBTOTAL HYPOPHYSECTOMY

This man was extremely fortunate that the long neglect and incorrect diagnosis of his condition was associated with a tumor that did not destroy all pituitary function and did not injure the brain, although three-fourths of the visual field had been lost.

The least damaged patient in this series is Mr. A. L.

**Case 5.**—The patient is an active business executive who, at age 46, experienced loss of libido. During the following year he noted fatigue and, finally, six months before operation, diminution of visual fields. The correct diagnosis was made at this time. Nine roentgen ray treatments were administered soon after the visual loss was discovered, at another hospital. There was temporary improvement, but two months later, sudden, marked limitation of vision occurred and he immediately presented himself for operation. Roentgenograms showed an enlarged sella, with an eroded floor. The visual fields displayed a bitemporal hemianopsia.

At operation (1937), curettage of a large hemorrhagic and partly degenerated tumor relieved the pressure on the optic nerve. He has since returned to work and has recovered vision and sexual activity. It is now three years since operation.

Endocrine studies, made last year (1939), found slight hypometabolism with normal thyroid function, as indicated by a blood cholesterol level of 234 mg. per cent; normal adrenal cortical activity; Wilder test 70 mg. per cent; normal sugar tolerance; absence of insulin sensitivity; and a normal condition of the genitalia and sex activity.

Of the seven patients with hyperpituitarism, none has developed hypopituitarism postoperatively; three have persistent hyperpituitarism, two of these, with manifest hyperthyroidism, diabetes and hypertension. All of this group, clinically, had acromegaly. In the three disabled patients, acromegaly was severe before operation; in the four well-adjusted patients, the development of acromegaly was slight.

As an illustration of mild hyperpituitarism the case of Mr. A. L. may be given.

**Case 6.**—The patient is a working man, age 36, who had an obvious and progressive acromegaly for ten years, but no disability until eight months prior to operation when severe headaches began. There was no loss of the visual fields but roentgenograms revealed a very large sella turcica. Preoperatively, there was no diminution of sexual function or loss of secondary sex characteristics. The preoperative metabolic rate was +9 per cent, and the blood-sugar level was high.

At operation (1938), there was no evidence of pressure on the optic nerves, and the tumor was small and inaccessible; only a small portion was removed. He made a good recovery, and returned to work, but has continued to have mild headaches. Several epileptiform seizures have occurred but these are controlled by bromides.

Endocrine studies, a year postoperatively (1939), showed hypermetabolism (basal metabolic rate +20 per cent), but normal blood cholesterol (244 mg. per cent) indicated normal thyroid functions. This deduction is permissible in view of the fact that the sugar tolerance curve was normal, that is, diabetes which might raise the blood cholesterol was absent. Adrenal function was normal, as indicated by a Wilder test result of 110 mg. per cent of urine. There was no insulin sensitivity. Gonadotropic function was normal as shown by sex activity and normal genitalia.

Mrs. F. H. illustrates the persistent form of hyperpituitarism.

**Case 7.**—The patient entered the hospital, at age 35, complaining of failing eyesight for two years; acromegalic changes in the face, hands, and feet for six years, premature

menopause and increased weight. At the same time, she had severe pain in her face and tongue, which occurred intermittently and lasted for several hours to one or two days and was not relieved by drugs. She had had no pain for two years prior to admission to the hospital. She had had occasional night sweats and had lost strength; she had stopped menstruating two years before. She had had severe headaches which stopped following roentgenotherapy of the pituitary.

Examination revealed a typical acromegalic woman, age 35. She was intelligent, rational, cooperative, oriented, and had a good memory for past and recent events. There was no ataxia, dysmetria, or loss of association of any muscle movements of the entire body. The visual fields showed a bitemporal hemianopsia, with contracted binasal fields; both disks were paler than normal and the margins were not sharply demarcated; the vessels were not engorged and there was no elevation of the disks. The head was long, with a prominent occiput; the skin of the face was rough, dry, and covered with blotchy markings. The nose was very large and the lower jaw protruded and was greatly enlarged. The tongue was large and filled the mouth more than in the average individual. The neck was full but symmetrical, and the thyroid was palpably enlarged and firm. The blood pressure was 154/96. The hair on the arms and legs seemed increased, and resembled that of a male. The hands and feet were very wide and thickened; the fingers and toes were enlarged and clubbed, and all of the joints of the extremities were enlarged. The patient had had a normal pregnancy five years before.

Roentgenograms of the skull showed a greatly enlarged sella turcica, with the posterior clinoid processes practically destroyed. The basal metabolic rate prior to operation was +17 per cent.

At operation (1932), the right optic nerve was found to be flattened out over a purple-domed tumor mass which pushed upward directly against the chiasm and did not extend forward between the optic nerves; the left nerve was likewise very flat. The dome of the tumor mass was incised, and immediately a large amount of soft, degenerated tumor material, together with dark yellow fluid, escaped. The tumor capsule collapsed and fell away from the chiasm. With the sucker and a curet, the tumor tissue was removed and the capsule was coagulated with the electrosurgical unit. The optic nerves and chiasm were thus freed from pressure.

The patient made an excellent postoperative recovery, and when dismissed from the hospital the fields of vision had enlarged remarkably. About two months later she began to menstruate again, and a year and a half later (1934) was delivered of a normal baby boy. After the child was born, menses resumed and continued regularly for two years, although the flow was scant; menstruation finally stopped again at age 39. For several months following operation Mrs. H. noticed that the size of her hands regressed considerably; previously she had been unable to fold her hands together because of the thickness of the fingers. She continued to be active and feel well for four years.

Three years ago (1937), five years postoperatively, symptoms of hyperthyroidism, hypertensive heart disease, and diabetes gradually became worse and cardiac failure occurred.

The endocrine findings were as follows: in 1939, seven years after operation: Hypermetabolism (basal metabolic rate +52 to +27 per cent); blood cholesterol elevated (276 mg. per cent); Wilder test normal; (60 mg. chloride per 100 cc.) of urine. This throws no light on hyperactivity of the adrenal cortex. The blood pressure has steadily risen from the nearly normal preoperative level to that of malignant hypertension. Cardiac hypertrophy, coronary insufficiency and congestive failure are in progress. It may be suggested that this is evidence of hyperfunction of the adrenal cortex. Sugar tolerance test found prolonged hyperglycemia indicative of pituitary diabetogenic activity (fasting blood sugar, 110, one-half hour, 216, one hour, 298, two hours, 292 and three hours, 172). Insulin tolerance did show some sensitivity; the blood sugar dropped from 120 to 75 mg. per 100 cc. of blood in three hours after ten units of plain insulin was given. Gonadotropic function was undetermined because the

## SUBTOTAL HYPOPHYSECTOMY

amenorrhea at this time is probably the normal menopause usually associated with hyperactivity of the pituitary. Since the recrudescence of hyperpituitarism corresponds with the menopause it may well be due to the withdrawal of the opposition that the ovary normally has for the pituitary.

In the hypopituitary group (Table I), hypometabolism is the rule; four are extremely low, between -30 and -40 per cent; 11 are in the neighborhood of -20 per cent; this is the level usually found in hypophysectomized animals, and two are near the zero per cent level. The blood cholesterol is significantly raised in all four patients with the lowest rates, indicating thyroid deficiency; however, in only six of the larger group, at -20 per cent, is it elevated, while in the remaining five it is normal, indicating that in these cases the hypometabolism is not associated with relative hypothyroidism. Thyroid administration would be of value in ten of these 17 patients, to judge by hypercholesterolemia.

Adrenal insufficiency was indicated by abnormally high chloride concentration in the urine at the termination of the Wilder tests, in five of the hypopituitary patients, as shown in Table I, and in one of the hyperpituitary group, as shown in Table II. Oddly, the two patients with the highest tests (as high as any found in fully developed Addison's disease) are in excellent clinical condition, carrying on normal lives. This suggests that in some way the hypopituitary state, under the usual conditions of life of these patients, avoids the sodium depletion of the body that leads to the crises which occur in patients with Addison's disease. The depletion is demonstrated by the Wilder test, but probably does not occur under ordinary conditions.

Consideration of the sugar tolerance curves brings out the expected lower curves; that is, greater tolerance to sugar in the hypopituitary group, but under the conditions present the flatness is rarely pronounced and the curves usually are entirely normal. Hence this test, in such cases, would rarely be of diagnostic value in establishing the hypopituitarism which is certainly present. The hyperpituitary cases, on the contrary, have a higher curve, that is, lower tolerance to sugar. This was most pronounced, of course, in the two patients with active acromegaly. Five of these seven patients have sugar tolerance curves that are abnormally high.

The insulin tolerance curves also brought out a distinct difference between the more and less deficient hypopituitary cases and the hyperpituitary cases. As was expected, the more hypopituitary patients had greater susceptibility to insulin. However, two of these patients maintained the blood sugar unchanged throughout the test. In the hyperpituitary group, three of the seven cases were unaffected by the insulin. One of these patients, however, had a marked insulin effect in combination with a high sugar tolerance curve.

Sexual function and the condition of the sex organs indicated great deficiency in all of the hypopituitary cases except three. In these, normal gonadal development and function were maintained. In the hyperpituitary group two were normal; two women, in addition, had amenorrhea and hot

TABLE I  
PATIENTS WITH HYPOPIITUITARISM

Patient*	B.M.R. —23	Blood Choles- terol 202	Wilder Adrenal Test 310	Sugar Tolerance			Insulin Tolerance			Blood			Op- eration 12/14/38	Clinical Condition Death 3/40	
				F 1/2	I 1	2 2	F 1/2	I 1	2 3	Gonad. Libido	Cal. Phos.	Cal. Phos.			
Mr. G. D.	—34	321	64	84	148	217	131	168	90	..	..	..	..	Mental deterioration	
Mr. D. C.	—34	316	100	..	..	..	..	..	68	47	55	51	4.5	Blind; mentally normal; severe physiologic deficiency	
Mr. H. R.	—22	303	60	..	155	120	168	112	88	..	52	..	50	Infantile	
Miss S. W.	—33	320	50	80	136	185	95	91	77	63	50	shock	..	..	
Mr. J. S.	—26	392	380	75	129	103	98	83	73	42	41	31	..	..	
Mr. L. H.	—40	..	..	..	..	..	..	..	..	..	..	..	..	..	
Mr. C. E.	—6	199	50	75	104	80	116	105	70	50	53	59	59	Small Diminished	
Mr. C. L.	—30	284	190	166	150	74	113	120	74	72	86	107	47	9.9	5.0
Mrs. C. P.	—21	189	76	..	..	..	..	..	..	..	..	..	..	4/22/39	
786 Miss M. H.	—18	324	70	60	121	104	99	110	78	54	43	shock	..	..	
Mrs. G. McD.	—19	306	50	92	148	222	151	137	130	95	75	50	..	..	
Mr. R. W.	—15	286	220	114	167	112	132	70	66	47	43	37	..	..	
Mr. H. E.	—14	282	568	87	154	125	90	84	71	73	67	70	..	..	
Mrs. M. O.	—18	312	..	80	123	94	103	93	80	66	44	53	50	..	
Mrs. M. S.	—20	239	50	84	177	97	122	99	88	80	67	33	61	..	
Mrs. S. S.	+·4	206	60	83	200	184	190	126	93	90	79	68	56	..	
Mr. J. S.	—21	215	428	80	164	178	96	125	80	77	73	75	70	..	
Mr. A. L.	—21	234	70	86	151	130	115	111	83	74	..	..	85	..	

\* Order of patients is graduated according to the estimation of their clinical condition; the worst at the top. B.M.R. on Abu-Dubois standard; blood cholesterol mg. per 100 cc. of blood; insulin tolerance on capillary blood after 100 Gm. of glucose; insulin tolerance on final four-hour urine specimen; sugar tolerance on capillary blood after 100 Gm. of plain insulin.

## SUBTOTAL HYPOPHYSECTOMY

TABLE II  
PATIENTS WITH HYPERPITUITARISM

Patient*	B.M.R.	Blood Cholesterol	Willer Adrenal Test	Sugar Tolerance			Insulin Tolerance			Blood			Op- eration	Date of Exam- ination		
				F	½	1	2	3	..	Gonad.	Lipid	Cal.	Phos.			
Mrs. R. H. +28	382	70	226	266	260	408	444	104	114	129	..	11.6	5.8	None	6/40	
				Hinsworth I+S										Hot flashes	1206 r units	
Mrs. F. H. +27	276	60	110	216	208	202	170	120	..	..	75	10.1	2.7	1/25, 32	2/40	
														Amenorrhea		
Mr. E. F. +15	202	236	137	276	286	154	167	102	83	65	67	4.2	Atrophy	Bone pathology	None	
Mrs. M. S. —8	335	144	86	253	160	173	117	82	93	80	79	78	Impotence	10.5	4.11	3/26
Mr. A. L. +20	244	110	104	152	104	110	75	110	81	79	100	10.7	Hot flashes	Amenorrhea	7/39	
Mrs. R. C. —1	248	68	111	200	222	143	111	115	125	132	102	117	Normal	..	1/27, 38	6/40
Mrs. W. S. Preop.	—9	..	74	92	214	184	121	95	88	90	96	71	Oligomenorrhea	..	..	1/22, 40
Mrs. W. S. Postop.	—19	246	60	80	126	201	114	131	85	76	77	52	Atrophy	10.7	2.8	7/40
														Amenorrhea		

\* Patients with acromegaly arranged in order of the severity of their clinical condition. Mrs. R. H., and Mrs. F. H. have persistent hyperpituitarism. Mr. E. F., and Mrs. M. S. are partially disabled. Mr. A. L., Mrs. R. C., and Mrs. W. S. are not incapacitated.

flashes, indicative of pituitary activity characteristic of the menopause; one male of the seven had impotence and atrophy similar to that of the deficiency group.

Our experience indicates that the diagnosis of hyperpituitarism, associated with nonfunctioning pituitary or embryonal tumors, is frequently missed. These tumors often produce irreparable cerebral damage and frequently extreme pituitary atrophy. The diagnosis would be made earlier if patients presenting signs of loss of sexual function and secondary sex characteristics were studied with this in mind. In women, amenorrhea and obesity are early results; in men, loss of libido and diminished beard growth occur in the incipient stage.

If cerebral damage is great, restoration of the patient is unlikely; if pituitary function is completely destroyed, substitution therapy is not successful.

Endocrine studies emphasize the loss of individual pituitary functions. These may be replaced by administration of the hormones of the glands normally maintained by pituitary activity; this is especially true of the thyroid. Thyroid therapy, while indicated and valuable, should be carried out cautiously. The objective should be the maintenance of a metabolic level correlated to the total functional state of the hypopituitary organism. This is at —20 per cent; that is, thyroid substitution should maintain normal metabolic processes at that level. Increasing the rate above this will place the hypopituitary patient in a state of relative hyperthyroidism, detrimental to other physiologic factors.

Hyperpituitarism may continue after operation and be difficult to control, or the acromegalic process may cease. The persisting disability may be due to hyperfunction of the subsidiary glands. The problem becomes one of controlling hyperthyroidism, diabetes and hypertension. If this does not occur, that is, if treatment successfully stops the hyperpituitarism, the result is satisfactory, and the energy production of the body and sexual function become adequate.

**DISCUSSION.—DR. WALTER WALTERS (Rochester, Minn.):** If the neurologic surgeons and those interested in neurology are not going to discuss Doctor Davis' paper I would like to do so. It seems to me that Doctor Davis' paper and the discussion of Dr. George Curtis, given this morning, on hyperfunction of the thyroid gland, indicates the present trend of surgical investigation.

Those who have been interested in surgical lesions of the ductless glands have been impressed by the frequency with which hyperfunctioning adenomata are absent in cases in which the clinical picture is one of hyperfunction of some gland. We are, therefore, often at a loss to explain why the clinical picture of hyperfunction of some particular gland is present, especially when, at operation, the gland in question appears to be normal. In our experience, less than 50 per cent of patients who present the clinical picture associated with hyperfunction of the cortex of the suprarenal gland are found to have hyperfunctioning adenomata at operation. In that group of cases of paroxysmal

## SUBTOTAL HYPOPHYSECTOMY

hypoglycemia in which hyperfunctioning adenomata of the islands of Langerhans are suspected, such tumors have been found in less than 50 per cent.

What is the explanation, and what are we going to do? It seems that by testing the function of the ductless glands prior to, or subsequent to, hypophysectomy, as Doctor Davis has done, data may be obtained which may assist in determining the cases in which the hypophysis is the disturbing factor and influences the action of the ductless glands.

I attended the meeting of the Central Society for Clinical Research recently. These men are as interested in surgical problems as we should be in medical problems, because they complement each other. Our functional study of the ductless glands is now in about the same phase as were studies of renal function in 1919. I believe the cooperation of internist and the surgeon will open these fields so that we, as surgeons, will be able to reach a better decision as to whether or not patients with lesions of the ductless glands should be subjected to operation. I believe Doctor Davis' statistics will serve as an example of the trend in surgical investigation of the future.

**DR. EMIL NOVAK** (Baltimore, Md.): Doctor Walters has apologized for discussing the studies of a neurologic surgeon, and surely a gynecologist should offer an even greater apology. And yet, many of the subjects discussed by Doctor Davis are encountered in the daily work of the gynecologist. A good example is the rather vaguely defined group of cases comprised under the designation of hypopituitarism, of which the adiposogenital dystrophy of Fröhlich is the most common type. The gynecologist encounters all sorts of variations of hypopituitarism. In the classic Fröhlich type, the patient presents a characteristically disturbed obesity, she is amenorrheic, and the uterus is hypoplastic. But we also see patients with exactly the same sort of obesity, who menstruate normally and bear many children. On the other hand, in certain cases of hypopituitary amenorrhea there is no obesity. Finally, either with or without obesity or amenorrhea we may or may not see disturbances of water balance, characterized by such phenomena as menstrual or periodic edema. My observation has been that in the Fröhlich cases the basal metabolic rate is within normal limits, though occasionally it may be slightly subnormal.

Recent investigations have shown that the metabolic disturbances of the Fröhlich syndrome have their source, not in the pituitary, but in the parapituitary areas of the midbrain, probably in the hypothalamus. This was suggested by the observations of Cushing and Teel, many years ago, as to the effects of tumors located in this area.

Doctor Davis spoke of substitution therapy for cases of this general type, but I am sure he appreciates the inadequacy of present-day substitution treatment for this indication. Thyroid is, of course, of value if there is an hypothyroidism, but this is not the usual rule. The pituitary hormones have not been isolated, we know nothing of their chemical structures, and we have no pituitary sex hormone preparations of established clinical effectiveness. In the case of the ovary, by contrast, the hormones have been isolated, we know their exact chemical composition, they can be prepared in crystalline form and we know much of their physiologic actions, so that they can be handled like the better understood drugs.

All this, however, does not detract from the importance of Doctor Davis' study, which represents a laudable effort to study a large group of pituitary cases from the standpoint of their physiologic and biologic connotations.

**DR. AMBROSE STORCK** (New Orleans, La.): Doctor Davis' reference to the influence of the pituitary on the thyroid brings to mind something we

have been doing for patients with hyperthyroidism who do not respond satisfactorily to the usual preoperative preparation. Because estrogenic hormones inhibit the production of thyrotropic pituitary hormone, diethylstilbestrol or other estrogenic substances have been given to a small number of cases which could not be brought into good condition by means of rest, calcium, iodine, a high caloric diet and vitamins. The number of cases in which we have observed apparently beneficial effects following this type of therapy is still very small, but the results so far have been at least encouraging.

DR. LOYAL DAVIS (Chicago, closing): I am very grateful for this discussion. It was the inadequacy of substitution therapy in many people that led us to attempt to determine, if possible, which one of the glands might be at fault. We found in many cases that substitution of thyroid helped immediately, and in other cases it did not. Theelin did more for one patient than any other type of therapy. It is the entire problem of substitution therapy that we are trying to investigate.

## PERFORATED PEPTIC ULCER\*

R. ARNOLD GRISWOLD, M.D.,

LOUISVILLE, KY.

AND

RUDOLPH F. ANTONCIC, M.D.

CLEVELAND, O.

FROM DEPARTMENT OF SURGERY, UNIVERSITY OF LOUISVILLE SCHOOL OF MEDICINE, AND LOUISVILLE CITY HOSPITAL,  
LOUISVILLE, KY.

THIS REPORT is an analysis of 111 consecutive cases of perforated peptic ulcer admitted to the Louisville City Hospital, from 1931 to 1940, with a description of our present treatment. The importance of the streptococcus in relation to mortality is stressed, and the local implantation of sulfanilamide is advocated. No comparison with statistics from elsewhere is attempted.

These patients were all charity patients from the low income group. There were 107 males and four females; 82 white and 29 colored. Corrected for the larger number of white patients admitted to the hospital, there was a ratio of white to colored of 4:3. Using the conventional grouping of months for the seasons, there were 37 cases in the Spring, 28 in the Fall, 24 in Summer, and 22 in Winter. The ages ranged from 18 to 73 years, with a median of 37.

There was no history of previous indigestion in 12 cases. In the others, ulcer symptoms had existed from three days to 30 years, with a median of four years. Four patients had had ulcer symptoms two, three, 11 and 12 years before, and then were symptom-free until perforation. One patient had been operated upon elsewhere for a perforation three years before we saw him. Another was operated upon twice by us for perforation, with an interval of two years. Sixty-one patients had employed alkalies, frequent feedings or both for the relief of symptoms, and 18 had been exposed to active medical treatment at some time or other. Three patients were on an active Sippy regimen, with subjective relief, at the time of perforation.

Definite increase of symptoms, three to 10 days before perforation, occurred in 68 per cent. Alcohol, particularly in the form of beer, seemed to be the precipitating factor in 11 patients. Perforation occurred during sleep (five patients), at work, on an empty stomach, and after meals. Only 65 per cent had vomited after perforation, and then usually only once or twice.

The temperature on admission varied from 96.5° to 103° F., averaging 98.8°; 55 per cent having a slightly subnormal temperature. The pulse rate averaged 94, and respirations 26 per minute. The average admission blood pressure was 129/79, only three patients being in shock, as indicated by blood pressure. Two of these were moribund and died within two hours.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

after admission. The small incidence of shock is emphasized, because of the general impression that shock is characteristic of perforated ulcer. The presence of pallor, and cold, clammy skin has caused many examiners to write "patient in shock," while recording a blood pressure of 120/80, with a pulse of 80. The fact that shock may, however, be imminent and easily precipitated, is shown by three patients in this series who suffered severe vascular collapse as the result of spinal anesthesia. Blood concentration studies would be of interest in this connection.

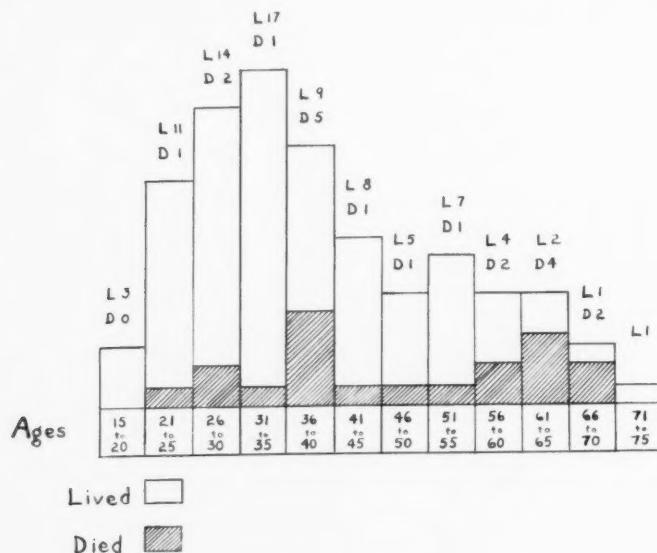


CHART 1.—The relationship between age and mortality.

Roentgenograms, in the erect position, showed subphrenic gas in 73 of the 97 patients so examined. Seventy-eight per cent had flat abdomens, with generalized rigidity. Eight patients had distention on admission, and all died of peritonitis. The remainder had spasticity in the upper epigastrium and often in the right lower quadrant. This latter finding led to seven preliminary diagnoses of acute appendicitis.

Nine patients in this series were not operated upon for closure of a perforation. Three of these with perforations of seven, seven, and six days' duration, were moribund on admission and died within a few hours. One, admitted 31 hours postperforation, had sealed off his ulcer and recovered under conservative treatment. Two, with perforation of 10 and 12 days' duration, were admitted with subphrenic abscess, empyema and pneumonia. They succumbed. Three refused operation. Two of these remained in the hospital five to seven days, sealed-off their ulcers spontaneously, and recovered. One left the hospital the day of admission and has not been traced. This is not, however, an argument for conservative treatment. One patient in the

## PERFORATED PEPTIC ULCER

operated group, whose ulcer apparently had sealed-off, on admission, was treated conservatively for several days. It perforated again, and he died following closure.

One hundred and two patients went to the operating room. The relationship of age to mortality in this group is shown in Chart 1, and of hours between perforation and operation, in Chart 2. These relationships are not unusual.

*Anesthesia.*—Eighty-eight patients were operated upon under spinal anesthesia. This has been discontinued in the later cases, because of two deaths on the table, and one shortly postoperative, due to vascular collapse. These patients were 58, 61 and 69 years of age, and had been perforated three days, three days, and seven hours, respectively. Eight patients were given general anesthesia, and the last six have been operated upon under novocain subcostal block, or intercostal block, as suggested by Bartlett<sup>7</sup>.

*Location of Ulcer.*—The site of perforation was recorded as being duodenal, 56 times; gastric, 45 times; and jejunal, once. This distinction, however, is not exact. Anatomic landmarks, such as the pyloric vein, are often obscured, so that the differentiation between duodenal and gastric lesions is inaccurate and may be impossible.

*Incisions.*—During the past few years, principally in an attempt to decrease wound and pulmonary complications, we have changed from the right rectus to the transverse incision, first, the Singleton,<sup>4</sup> or Sanders,<sup>5</sup> muscle-retracting type; then the muscle-cutting incision, advocated by Lynn<sup>6</sup> and, finally, one-half the Lynn incision (Fig. 1). This is a short, high transverse or oblique skin incision over the right rectus, which cuts all layers transversely. This small incision gives adequate exposure for suture of an ulcer and may easily be extended to care for any lesion in the upper abdomen if necessary. It allows painless respiration, encourages adequate pulmonary ventilation and heals well.

*Operations.*—The different types of operation carried out, and their mortality rates, are shown in Table I. With three exceptions, these were all carried out by the resident staff of the Louisville City Hospital, under only moderately close supervision.

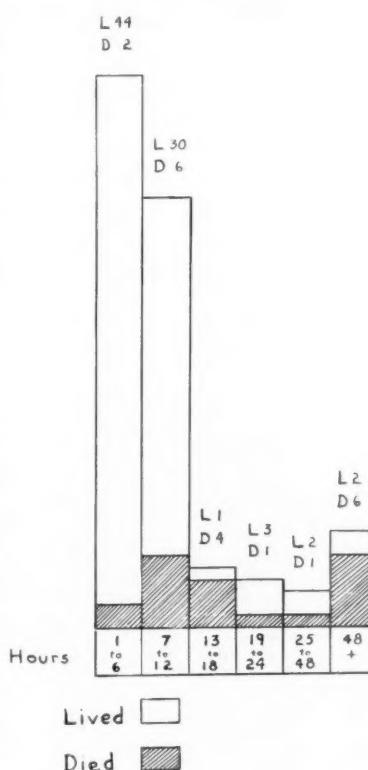


CHART 2.—The relationship between hours from perforation to operation and mortality.

It is evident that simple closure carries a lower mortality than excision of the ulcer with transverse suture (pyloroplasty). Follow-up shows that this more radical procedure is no more likely to prevent recurrence of the ulcer than is simple suture. Of the 20 patients who survived excision and

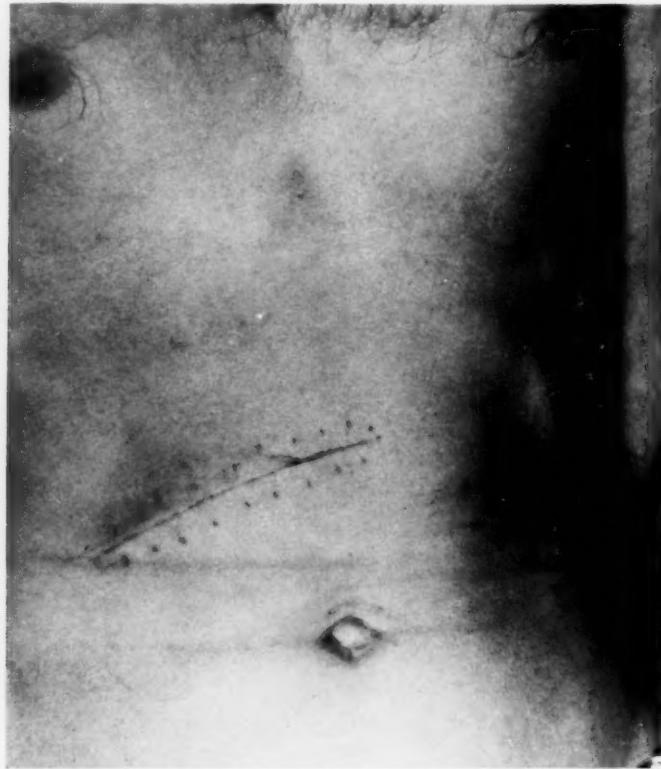


FIG. 1.—Photograph showing the short transverse incision. This particular illustration shows an incision which is a little more oblique than the one usually employed. It divides all structures transversely.

pyloroplasty, there have been five (25 per cent) known recurrences, with two subsequent resections. In the group of 60 simple closures, there have been 11 (18.3 per cent) known recurrences. The one closure, with gastro-

TABLE I  
OPERATIVE PROCEDURES EMPLOYED

Operative Procedure	Lived	Died	Total
Simple closure:			
Lembert or Cushing 40 }	60	12	72
Purse-string 20 }			
Excision and pyloroplasty.....	20	6	26
Purse-string and enterostomy.....	—	1	1
Purse-string and gastro-enterostomy.....	1	—	1
Subtotal gastric resection.....	1	—	1
Spinal death before closure.....	—	1	1
Totals.....	82	20	102

## PERFORATED PEPTIC ULCER

enterostomy, was followed by gastrojejunal ulcer. The patient who underwent resection was free of symptoms after one year. This patient was in the hospital for resection, and perforation occurred on the ward early the morning of operation.

It is felt that simple closure, with Lembert or Cushing sutures, when necessary following the procedure described by Gatch,<sup>1</sup> is the preferred operation. Purse-string closure is more apt to encroach upon the lumen of the pylorus. One of the patients in this series, whose perforation was closed by chromic catgut purse-string sutures, had a stormy convalescence on account of pyloric obstruction. He was readmitted to the hospital a year later on the Medical Service, and died of obstruction, without surgery.

*Drainage.*—Intraperitoneal drainage was employed in only seven cases, twice in the upper abdomen, three times in the pelvis, and once in both. Such drainage was used, principally, in late cases (six, eight, 16, 20, 48, 84 and 120 hours), and with decreasing frequency in recent years. Four of the seven drained cases ended fatally. Drainage of extraperitoneal tissues alone was employed in 14 cases. This has been discontinued, since the use of sulfa-nilamide, as will be described later.

*Bacteriology.*—Culture reports from the peritoneal fluid were available in 65 instances. No growth was reported 34 times. The streptococcus or streptococcal mixtures were reported 18 times; staphylococcus, seven times; colon bacilli and diphtheroids, twice each, bacillus aerogenes and pneumococcus, once each. There was some correlation between the hours postperforation and positive cultures, but this was not as marked as might be expected. Negative cultures were reported in cases from one to 72 hours postperforation, with a median of five hours; while the infected cases ranged from one to 84 hours postperforation, with a median of eight hours. The influence of positive culture, particularly streptococcus, on mortality, was much more marked than can be explained by the slight increase in time. Of the 31 cases with positive culture, there were nine fatalities. Eight of these were associated with streptococcus. Of the 34 patients with negative cultures, only three died. These three were operated upon 14, 19 and 72 hours after perforation. Two of the three died of pulmonary complications and the third was one of the spinal anesthesia fatalities.

The relation of bacteriology to mortality is shown in Table II.

TABLE II  
RELATION OF BACTERIOLOGY TO MORTALITY

Type of Infection	Lived	Died
Streptococcus.....	10	8
Staphylococcus.....	6	1
<i>B. Coli</i> .....	2	0
Diphtheroids.....	2	0
<i>B. Aerogenes</i> .....	1	0
Pneumococcus.....	1	0
No growth.....	31	3
No culture.....	29	8
Totals.....	82	20

*Causes of Death.*—The chief causes of death were as follows:

TABLE III

## CAUSES OF DEATH

Peritonitis .....	10
Pneumonia.....	4
Atelectasis and pneumonia.....	2
Circulatory collapse (spinal).....	3
Streptococcus septicemia.....	1
Total.....	20

*Complications.*—Two of the patients who died, lived a sufficient length of time to observe the progress of wound healing. In these 84 patients, wound results were as follows:

TABLE IV

## WOUND RESULTS IN 84 CASES

Primary healing .....	55
Wound infection (one hernia).....	28
Wound disruption .....	1
Total.....	84

Nonfatal complications, aside from peritonitis and wound infection, were: Pneumonia, two; delirium tremens, two; massive atelectasis, one; parotitis, one; postoperative pyloric obstruction, one.

*The Use of Sulfanilamide.*—As soon as this survey was well under way, the close relationship between the streptococcus and mortality was evident. Accordingly, the local use of sulfanilamide in this, as well as in other contaminated abdominal conditions, seemed advisable. This drug has been advocated by Jensen,<sup>2</sup> and others,<sup>3</sup> in contaminated wounds of the extremities. For the last several months, we have used it in the abdomen whenever contamination was present, including such conditions as perforated peptic ulcer, perforated appendicitis, gunshot wounds of the abdomen, or on other occasions when the lumen of the gastro-intestinal tract was opened. The amounts used have been 5 to 10 Gm. of sulfanilamide crystals in and around the lesion in the peritoneal cavity, and 2 to 5 Gm. in the abdominal wall. The results in the last 12 cases of perforated ulcer and in other abdominal lesions have been encouraging. In the 12 perforated ulcers, in which sulfanilamide was used locally, there was one death. This patient had been perforated three days, and collapsed following spinal anesthesia. There were two mild wound infections. Sulfanilamide by other routes was not administered in these cases, as we wished to study the absorption of the drug from the peritoneal cavity. This absorption is quite rapid. Estimations of blood concentration usually show a peak of 6 mg. or more per 100 cc. of blood, in about four hours, with gradual disappearance from the blood stream within 24 to 48 hours. One patient, not included in this series, who had 10 Gm. implanted in the pelvis and five Gm. in the abdominal wall, reached a concentration of 22.4 five hours after implantation. Peak concentrations of 10 mg. or more are not unusual. A typical blood curve is shown in Table V.

## PERFORATED PEPTIC ULCER

TABLE V

## TYPICAL CURVE OF SULFANILAMIDE BLOOD CONCENTRATIONS

Patient C. Q., No. 15439—7/8/40

	5 Gm. implanted
1:20 A.M.	Free, 6.20 Total, 7.42
5:30 A.M.	" 5.29 " 6.44
9:00 A.M.	" 4.44 " 6.20
12:00 Noon	" 3.45 " 6.20
3:00 P.M.	" 2.30 " 5.29
6:00 P.M.	" 2.00 " 3.26
9:00 P.M.	

The high blood concentrations obtained would suggest systemic as well as local effect from the drug, although it seems likely that the saturated solution in the peritoneal cavity in direct contact with the bacteria is most effective. Maintaining the high blood concentration by other routes is, of course, advisable.

*Present Procedure.*—Our present treatment has been evolved gradually from our own experience and a study of the literature. It is as follows:

- (1) A short transverse incision under novocain block anesthesia, supplemented when necessary by a small amount of cyclopropane.
- (2) Thorough removal of intraperitoneal fluid, including that in the pelvis, by suction rather than sponges.
- (3) Simple closure of the ulcer with two layers of interrupted silk sutures from the proximal to the distal side of the ulcer, so as not to encroach upon the lumen of the pylorus. This suture line is reenforced by catching omentum in the outer layer of sutures. The procedure advocated by Gatch<sup>1</sup> is utilized when necessary.
- (4) Five to 10 Gm. of sulfanilamide crystals are sprinkled about the lesion and 3 to 5 Gm. are implanted in the abdominal wall.
- (5) No intraperitoneal drains are used.
- (6) The abdominal wall is closed in layers with silk, without drainage, and a nonconstricting dressing applied.
- (7) A Levine tube is passed into the stomach just before or after operation—to remain 24 to 48 hours. If ileus from peritonitis supervenes, the use of the tube is continued.
- (8) If the peritoneal culture shows streptococcus, sulfanilamide is pushed by any available route.
- (9) Pulmonary complications are combated by such measures as frequent turning of the patient, carbon dioxide inhalations, and bronchoscopic aspiration, if atelectasis occurs.
- (10) Salt and fluid balance are carefully controlled.
- (11) Transfusions of blood or plasma are administered freely when indicated.

## SUMMARY

- (1) Analysis of 111 cases of perforated peptic ulcer shows that, aside from the age of the patient and delay in operation, the most important factor

in mortality is the presence of the streptococcus in the peritoneal cavity. Next in importance are pulmonary complications.

- (2) The use of sulfanilamide locally and systemically is advocated.
- (3) Our present method of treatment is described.

#### REFERENCES

- <sup>1</sup> Gatch, W. D., and Owen, J. E.: ANNALS OF SURGERY, **105**, 750, May, 1937.
- <sup>2</sup> Jensen, N. K., Johnsrud, L. W., and Nelson, M. C.: Surgery, **6**, 1, July, 1939.
- <sup>3</sup> Key, J. A., and Burford, T. H.: South. Med. Jour., **33**, 449, May, 1940.
- <sup>4</sup> Singleton, A. O.: South Med. Jour., **24**, 200, 1931.
- <sup>5</sup> Sanders, R. L.: ANNALS OF SURGERY, **104**, 74, July, 1936.
- <sup>6</sup> Lynn, F. S., and Hull, H. C.: ANNALS OF SURGERY, **104**, 233, August, 1936.
- <sup>7</sup> Bartlett, Robt. W.: Surg., Gynec., and Obstet., **71**, 194, August, 1940.

**DISCUSSION.**—DR. AMBROSE STORCK (New Orleans, La.): A study of perforating peptic ulcers has just been completed at Tulane by Doctors Ochsner and DeBakey. Some of the findings, based on approximately 23,000 cases which have been previously reported by various authors, as well as on case records at the Charity Hospital in New Orleans, were graphically shown in lantern slides. The incidence of perforation in peptic ulcer in the cases collected from the literature was 13.2 per cent, whereas in the Charity Hospital cases it was 8.09 per cent. Charity Hospital records reveal an increase, in recent years, in the percentage of perforation of peptic ulcers. Whereas perforating duodenal ulcer occurs most frequently in the age-group between 20 and 40 years, the peak incidence of perforation of gastric ulcer is in individuals about 50 years of age. In 11,305 cases in which the location of the perforation was accurately recorded, 51.2 per cent were duodenal, 38.9 per cent were gastric, and 9.8 per cent were "pyloric."

There was a constant, direct relationship between the death rate and the age of the patients, and the mortality increased progressively in relation to the number of hours elapsing between the time of perforation and the time of operation. Although the mortality was highest in the group of cases in which local anesthesia was employed, it must be kept in mind that this type of anesthesia was probably frequently employed in cases of long duration or in poor risk patients. The relatively low mortality in the cases in which spinal anesthesia was administered suggests that this type of anesthesia is preferable to general anesthesia. The mortality incidence following various operations was as follows: Simple closure, 25.9 per cent; closure plus gastro-enterostomy, 20.4 per cent; excision plus closure or pyloroplasty, 15.9 per cent; and gastrectomy, 13.5 per cent. The relatively high mortality following simple closure was no doubt due to the employment of this procedure in the majority of patients who were in poor condition. On the other hand, the very low mortality following gastrectomy reflects the skill and experience of the relatively few surgeons who employed this method. Excision of the ulcer plus closure of pyloroplasty, while not an operation of great magnitude, is effective not only as a means of meeting the problem of perforation, but the follow-up results following this type of procedure are very satisfactory. The relatively poor follow-up results following simple closure might be reduced if more of the patients in which this procedure is employed were properly instructed in regard to proper postoperative regimen. In 942 cases in which the cause of death was definitely stated, peritonitis was found in 57.1 per cent; pulmonary lesions were present in 20.7 per cent; and other causes were reported in 22.1 per cent.

## PERFORATED PEPTIC ULCER

DR. R. L. RHODES (Augusta, Ga.): There is not much to add to Doctor Griswold's paper, but I wish to report a most unusual case with several particularly interesting features:

**Case Report.**—A young man, age 17, who had been milk-fed all his life; the exclusion of practically all vegetables; multiple perforations; exception to the old dictum that a peritoneum once insulted is difficult to insult again; and the extraordinarily prolonged effects of eucupin as a local anesthetic.

The first perforation occurred at 1:30 A.M., May 28, 1936. I saw him at 4:30 A.M., and sent him at once to the hospital, where a roentgenogram did not show a gas or air bubble beneath the diaphragm. He was operated upon at 7:30 A.M., and a perforation on the anterior border of the duodenum, one inch from the pylorus, was easily closed with mattress sutures of catgut. Convalescence was uneventful, and he left the hospital on the eighteenth day.

On October 30, 1936, at noon, while on his way home to lunch he was seized with an acute, prostrating pain in his epigastrium, which eased off after reaching home and lying down. At 3 P.M. it recurred and continued until his physician arrived and gave him morphine for relief. I saw him a little later, at which time he told us of a similar attack two weeks previously which, however, remained eased after he lay down for an hour or two. He was sent to the hospital where a roentgenogram, again, failed to show gas or an air bubble beneath the diaphragm.

Operation, at 7 P.M., revealed a diffuse peritonitis and an actively leaking perforation in the duodenum, two inches from the pylorus, one inch beyond the scar of the former perforation. About one inch further, the duodenum was adherent to the under surface of the liver and snugly covered with omentum. The perforation was closed as in the former instance. The adherent omentum was then freed from the liver and the duodenum carefully separated, when we opened into an abscess of about two drams of pus, and revealed a perforation one-quarter inch in diameter in the duodenum, which was closed. This perforation probably accounted for the acute pain two weeks previously, but sealed itself against the under surface of the liver. Two cigarette drains were introduced, and brought out through a stab wound in the flank. The incision was closed in layers with chromic catgut and several through-and-through silver wire tension sutures were inserted.

His convalescence was most stormy—through the gamut of a diffuse peritonitis; the wound laid wide open; the silver wires cutting out; and resulting evisceration. This was controlled by a rubber sheet dam with rolls of gauze packed in the gutter and snugly strapped with adhesive. After three weeks he began to improve and was allowed to go home four weeks later, where he remained in bed until the wound was completely healed, four months after operation. Most of the right rectus muscle and fascia had sloughed away and he had a large hernia, three inches wide and the full length of the incision. For this he was given an elastic girdle which he wore for about a year, not only to help hold the hernia but to prevent or lessen further retraction of muscles of the right side of the abdominal wall.

On March 26, 1938, the third operation, closure of the hernia, was performed under local anesthesia field block and infiltration, using eucupin procaine solution. This operation, as you know, was necessarily quite tedious and slow, required about five hours and is why local anesthesia was selected, as well as to avoid all involuntary muscular effort such as coughing, etc. The edges were freed and approximated where possible and flaps of left rectus fascia where necessary, and dozens of silk sutures were used, until closure was satisfactory. Examined last week, he was found to be in excellent physical condition, without any evidence of hernia. I was particularly impressed by the prolonged effect of the eucupin and commend it to your consideration.

DR. A. O. SINGLETON (Galveston, Tex.): There are many phases of this question which one may discuss. I would like to call attention to perforating

gastric and duodenal ulcers in the newborn. They are quite common, and apparently not very frequently diagnosed and operated upon. About two years ago we operated upon an infant three days old, with a perforated gastric ulcer. About three months ago we operated upon one 14 hours old. Both babies died of peritonitis. The literature reports many having been found at autopsy. Lee reported one stomach ulcer perforated *in utero*. Many ulcers have been found at autopsy which have not been perforated.

The cause of these perforations is very interesting to speculate upon: The first symptom noted is distention. More positive diagnosis can be made if roentgenograms reveal free gas in the peritoneal cavity. We were hopeful we would find one upon whom operation could be performed without delay, as we felt the delay was the cause of death of the first one. So we operated upon the second case early, but it also died from peritonitis. Whether chemotherapy would have helped we do not know, but if we have another we will use sulfonamide, as suggested by Doctor Griswold.

DR. J. M. T. FINNEY, JR. (Baltimore, Md.): We hear, from time to time, about familial tendencies in various conditions, and I would like to put on record three cases, brothers, upon whom I have operated for perforated ulcer, at one time or another. Two of these had perforations without any obtainable previous history of ulcer; the third had had stomach trouble for many years. In all three, the perforations occurred between the ages of 70 and 72, and in no instance was malignancy found. I am glad to say they all survived. That is the only instance of perforated ulcer in three members of the same family that I know of.

I would like to call attention to an article published some years ago in *Surgery, Gynecology and Obstetrics* by a member of this Association, Doctor Robert T. Miller, Jr., in which he advocated cutting the round ligament of the liver under the umbilicus, but leaving it attached to the edge of the liver, and using the cut end as a plug in the hole, where induration makes a stitch almost impossible, and the surrounding tissue is difficult to use. The round ligament has fibrous tissue in its structure and makes an excellent plug where one has difficulty closing the perforation by simple suturing. I have employed this technic on numerous occasions, with great satisfaction.

DR. JOSEPH M. DONALD (Birmingham, Ala.): Treatment of perforated duodenal ulcer by excision of the ulcer followed by a Judd pyloroplasty has been employed in approximately 40 per cent of such cases admitted to the Hillman Hospital during the last seven years. This procedure is reserved for those patients in whom the perforation is of less than eight hours' duration, and in which the duodenum is easily accessible. Our mortality rate following this type of treatment has been less than that following simple closure. This, of course, is due to the better-risk patient. However, we have found it possible to obtain a much better closure of the duodenum following excision of the ulcer than is the case following simple closure, when the sutures so frequently cut through the friable tissue around the perforation. The fact that many of the surgeons on the staff of the Hillman Hospital prefer excision and pyloroplasty to simple closure in selected cases, speaks well for the procedure.

Regardless of the type of operation, recurrence will occur in a small percentage of cases. In one patient, in whom the ulcer was excised and pyloroplasty performed, a second perforation occurred in the same portion of the duodenum, three years later.

I was particularly interested in Doctor Griswold's remarks relative to

## PERFORATED PEPTIC ULCER

the absence of shock in instances of perforated duodenal ulcer. I have seen only one case in which shock was present in the early stage of perforation. This patient was seen with Dr. H. E. Simon. He was an elderly male, and was in extreme shock from the very onset of pain. His condition did not permit exploration and death occurred within 24 hours. Autopsy revealed two large, perforated duodenal ulcers, which had apparently perforated simultaneously. Ordinarily shock is present only in the late cases associated with generalized peritonitis.

Finally, I would like to reemphasize the importance of the transverse abdominal incision in cases of perforated duodenal ulcer, as recommended by Doctor Griswold. In a recent study of wound disruptions, I was surprised to find that of 32 such cases, six (approximately 20 per cent) followed right rectus incisions for perforated duodenal ulcer.

DR. R. ARNOLD GRISWOLD (Louisville, Ky., closing): I have very little to add except a note about the difficulties of simple suture in cases with a large area of indurated, friable tissue surrounding the ulcer. Sutures tear out of this tissue very easily. In these cases we have employed the technic which Gatch reported before this Association in 1936, in which the anterior wall of the stomach is sutured to the anterior wall of the duodenum, thus closing over the ulcer without introducing sutures through the friable tissue. Since we have been employing this simple method we have not seen a case which could not be closed without resorting to excision and pyloroplasty or other more radical procedures.

## RESECTION OF THE DUODENUM FOR TUMOR OF THE AMPULLA OF VATER\*

J. SHELTON HORSLEY, M.D.

RICHMOND, VA.

FROM THE SURGICAL DEPARTMENT OF ST. ELIZABETH'S HOSPITAL, RICHMOND, VA.

CANCER of the head of the pancreas or cancer of the ampulla of Vater or duodenum, invading the head of the pancreas, was considered a necessarily fatal condition until about 22 years ago, when Coffey<sup>1</sup> first devised an operation for resection of the head of the pancreas and the duodenum. It was,

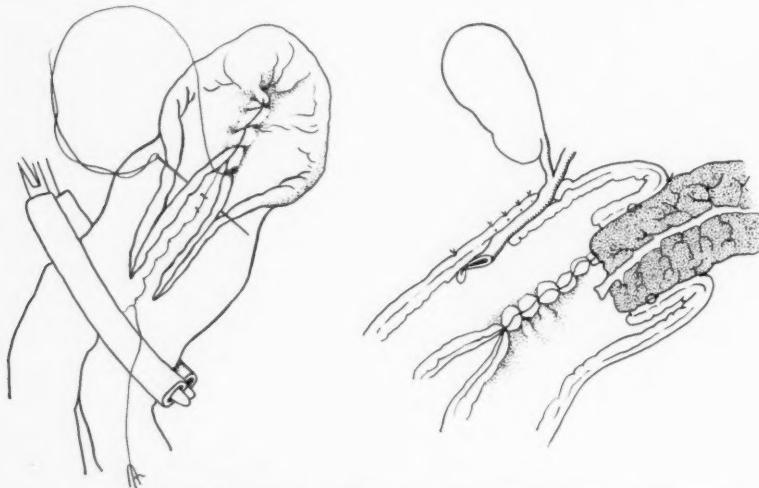


FIG. 1.—The Coffey method of resection of the duodenum and head of the pancreas. A receptacle is made for the stump of the pancreas out of a loop of jejunum. The common duct is obliquely inserted lower down.

for a time, thought that resection of the duodenum must be fatal because of the loss of some vital secretions. Coffey disproved this in his experiments on dogs. I do not know of any patient that Coffey operated upon, though his experimental work on the lower animals and that upon the cadaver was extensive. He provided in the jejunum a receptacle for the stump of the pancreas after the duodenum and the head of the pancreas had been excised. He transplanted the common bile duct obliquely into the jejunum lower down (Fig. 1).

In 1922, Frank C. Mann and Kyoichi Kawamura<sup>2</sup> published a paper on an experimental study of duodenectomy. They developed a technic for excision of the duodenum and transplantation of the common duct and the pancreatic duct. Most of the work was done upon dogs, in one stage. They

\* Read before the Fifty-third Annual Session of the Southern Surgical Association, Hot Springs, Va., December 12, 1940.

## TUMOR OF AMPULLA OF VATER

reported that no noticeable change followed duodenectomy except that in two of ten dogs a typical peptic ulcer developed on the jejunal side of the gastro-jejunal anastomosis. Apparently, excision of Brunner's glands had no perceptible effect.

Dragstedt, Clark and Vermeulen<sup>3</sup> have developed an extract from the pancreas which they named "lipocaic." This extract when fed to dogs which have developed fatty liver after excision of the pancreas restores the histology and the function of the liver to practically normal. Apparently feeding fresh pancreas does the same. They seem to have demonstrated that it is this

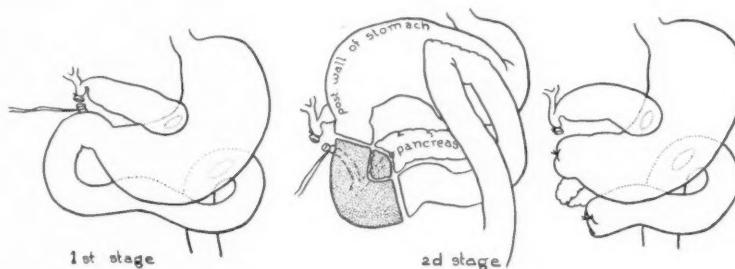


FIG. 2.—Original technic of operation by Whipple, Parsons and Mullins. In the first stage the gallbladder is united to the stomach; the common duct is doubly ligated and divided; and a posterior gastro-enterostomy performed. In the second stage the duodenum and the head of the pancreas are excised; and the pancreatic duct is ligated. Then both stumps of the duodenum are closed; and the stump of the pancreas is sutured.

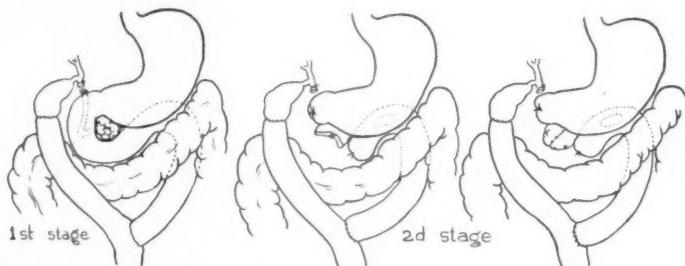


FIG. 3.—Whipple's modification of the operation shown in Figure 2, in which the gallbladder is united to the jejunum instead of to the stomach.

extract and not cholin or lecithin that is responsible for this reaction. They believe that the absence of pancreatic juice from the intestine is relatively unimportant, and leads only to partial impairment of digestion or absorption, whereas the absence of the internal secretion lipocaic or insulin is incompatible with life. The ligation of the pancreatic duct does not appear to affect the internal secretions of the pancreas, lipocaic and insulin.

The physiologists have shown that the external secretion of the pancreas is not essential to life, and based upon this fact the surgical technic for excision of the duodenum and the head of the pancreas is appreciably simpler.

Whipple, Parsons and Mullins<sup>4</sup> were pioneers in advocating operation founded on this principle. Their original operation was undertaken in two

stages: The gallbladder was first anastomosed to the stomach, a gastro-enterostomy was performed, and then, at a later stage, the duodenum and the head of the pancreas were excised and the pancreatic duct was ligated (Fig.

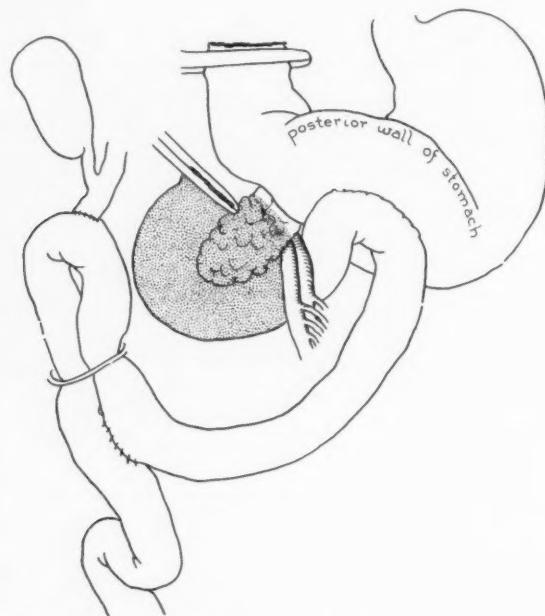


FIG. 4.—The final modification that Whipple has made is to unite the common duct, instead of the gallbladder, to the jejunum.

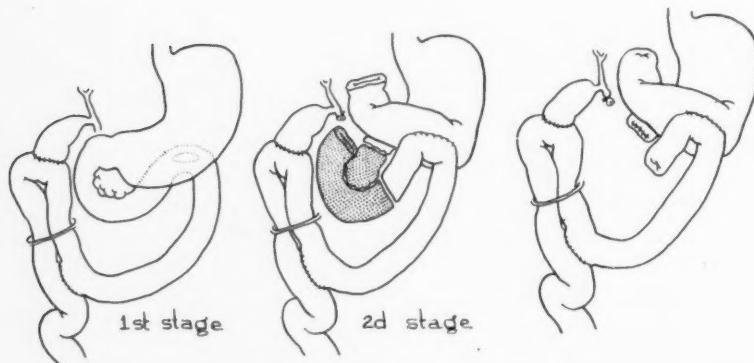


FIG. 5.—Brunschwig's operation is much like the second modification of Whipple, except that the jejunum is brought through the mesentery of the transverse colon.

2). Whipple modified this by uniting the gallbladder to the jejunum instead of to the stomach. He divided the jejunum about 10 to 12 cm. below its origin; transplanted the proximal end into the side of the jejunum farther down; and then united the gallbladder to the lower stump (Fig. 3). He later

## TUMOR OF AMPULLA OF VATER

found that there might be a troublesome leak in the ligated stump of the common duct, so he abandoned this procedure, and he now unites the end of the common duct to the jejunum<sup>5, 6</sup> (Fig. 4). Whipple believes that patients in whom the pancreatic duct is ligated do not suffer materially from suppression of the pancreatic juice or from fatty degeneration of the liver.

Brunschwig<sup>7</sup> has advocated a technic for excision of the duodenum and head of the pancreas in which a loop of jejunum is brought up through the transverse mesocolon and united to the gallbladder (Fig. 5).

Baggenstoss<sup>8</sup> reports that papillomata of the ampulla of Vater are apparently more frequent than is generally recognized. They often create no symptoms, but because of the peculiarities of the structure of the large papillomata of the ampulla of Vater they probably are in close relationship with carcinoma.

**Case Report.**—No. B-8421: D. C., white, male, age 60, had a history of intense jaundice for about seven weeks. He had, apparently, been in good health until February 20, 1940, when he noticed that his urine was highly colored. On March 11, 1940, he went to his physician, who gave him medical treatment. He gradually became more deeply jaundiced. His urine was highly colored and concentrated, and he had a generalized pruritus. The stools were clay-colored. He had two attacks of severe, non-radiating pain in the upper abdomen. They were relieved by hypodermics. The patient stated that he had had a similar attack about 15 years ago, which cleared up under medical treatment.

*Physical Examination.*—The patient was deeply jaundiced, with an icterus index of 180. There were numerous areas of superficial abrasions from scratching. The abdomen was distended. The patient was rather stout. It seemed probable that there was a stone in the common duct, though cancer of the head of the pancreas could not be excluded. The liver was palpable on deep inspiration. There was moderate pain over the region of the gallbladder. The pulse rate was 72, and the blood pressure was 110/40. He was kept in the hospital three days, and given preliminary treatment, including vitamin K and bile salts.

*Operation.*—April 16, 1940: The gallbladder was dilated and adherent. The adhesions were separated. The gallbladder was opened and found to contain a quantity of thick fluid that appeared to be chiefly mucus. It was explored with the finger. There were no stones, and no stones could be palpated in the common duct. The duodenum was contracted and contained a small mass about the region of the ampulla of Vater. The head of the pancreas was slightly infiltrated, but, on the whole, the growth seemed to be easily resectable. It was decided to remove a segment of duodenum with the attached portion of the pancreas. The duodenum was mobilized, and occluded with a rubber band well below the growth. It was divided a short distance below the growth and a protuberance was seen apparently originating from the ampulla of Vater. It was fairly well fixed, and there was infiltration into the pancreas beneath this. The duodenum was also divided with the cautery a short distance below the pyloric sphincter, and this isolated segment of the duodenum including the tumor, and with a portion of the attached pancreas, was removed with the cautery. The tissues were quite vascular, but the bleeding was easily controlled. The end of the common duct was greatly dilated, permitting the entrance of the finger. It poured out "white bile," without a tinge of color. The pancreatic duct came out of the stump of the pancreas a short distance from the common bile duct and was not dilated.

It seemed possible to make an end-to-end union of the lower stump of the duodenum, which was rather small, with the greatly dilated common duct. The posterior margin of the lower stump of the duodenum was sutured to the posterior margin of the dilated

common duct with interrupted sutures of fine silk (Fig. 6), which were also placed anteriorly. These sutures puckered the duodenum considerably. Anteriorly, and on the side, additional sutures of silk were inserted. Over these sutures interrupted sutures of fine chromic catgut brought over the duodenum so the entire stump of the pancreas was covered. The ends were left long. In this way there was a union of the puckered lower end of the duodenum to the large common duct and the pancreas. No effort was made to secure the pancreatic duct separately. It was apparently not enlarged. By the outer row of sutures, the duodenum was attached to the margin of the stump of the pancreas so that the duct of the pancreas would probably drain into the loose

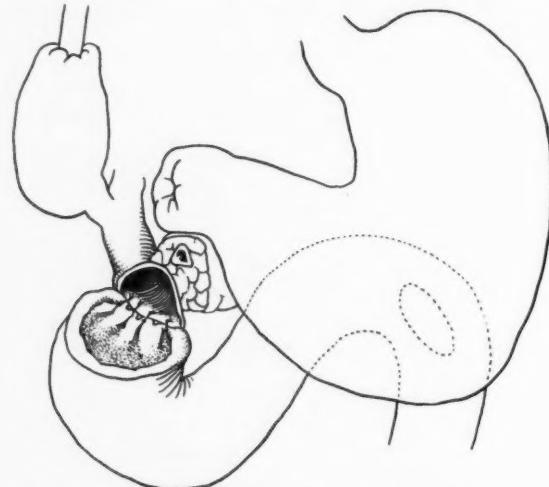


FIG. 6.—In the operation performed in the reported case, the distal stump of the duodenum was sutured to the greatly enlarged common duct. The undilated pancreatic duct is shown in the stump of the pancreas near the common bile duct.

anastomosis of the common duct and the duodenum. Thus, there were anteriorly three layers of sutures—two of interrupted sutures of silk, and the outer row of interrupted sutures of fine chromic catgut. All of the raw surface of the stump of the pancreas was covered. (Fig. 7.) The ends of the outer row of sutures, which were of fine chromic catgut, were threaded in a needle and passed through a tag of omentum so that the union was well reenforced.

The upper end of the duodenum was folded in and sutured, and a posterior gastroenterostomy was performed. As the gallbladder had already been opened, a drainage tube was placed in it. A stab wound was made in the right flank, and a rubber tube and a cigarette drain were placed down to the region of the foramen of Winslow.

*Postoperative Course.*—The patient stood the operation remarkably well, and left the table with a pulse of 88. For the first 36 hours his convalescence appeared to be entirely satisfactory. On the afternoon of the day after the operation his temperature was 99° F., pulse 94. The secretion of urine, however, was failing. On the fourth day he passed only 15 cc. of urine. He died on the fifth day after operation, his temperature reaching 103.5° F., pulse 160, just before death.

*Necropsy.*—The healing around the site of the anastomosis was in good condition. There was intense jaundice. About 300 or 400 cc. of bile-tinged fluid was found in the peritoneal cavity. There was no evidence of peritonitis or leakage of the sutures at any point. There were some partly organized blood clots in the head of the pancreas, and slight evidence of necrosis where the cautery had been used, but there was no infection in this region. The kidneys were slightly enlarged and deeply stained with bile, and their surfaces indicated nephritis. The liver was enlarged. The lower lobe

## TUMOR OF AMPULLA OF VATER

of the right lung was compressed, and the lower lobe of the left lung was almost solid, from what seemed to be hypostatic pneumonia. The patient apparently died of uremia.

*Pathologic Examination.—Gross:* The specimen consisted of the segment of the duodenum, which measured 4.5 cm. in length. Attached to it is a portion of the pancreas. From the region of the ampulla a protuberance, 1.5 cm. in length and 1 cm.

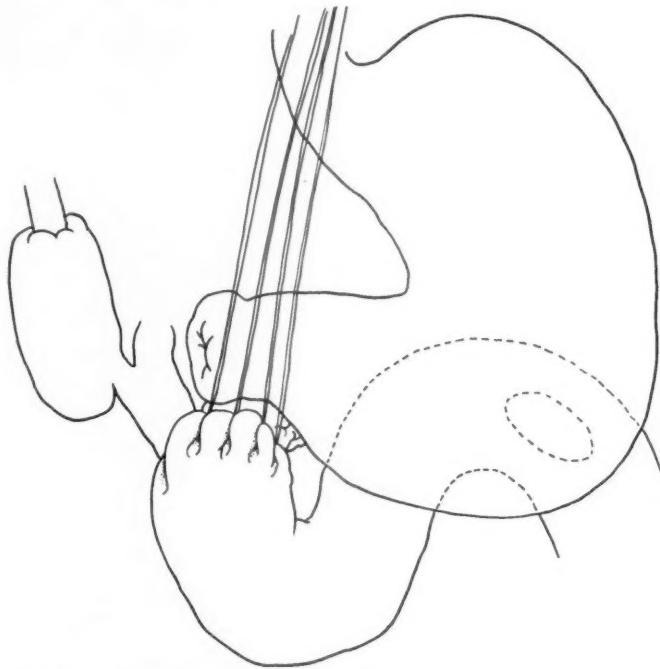


FIG. 7.—The anterior sutures between the duodenum and the end of the common duct have been inserted. Another row of silk sutures is placed around this, and the final row of sutures of fine chromic catgut is being inserted so as to fold over the duodenum and cover the stump of the pancreas. Finally, the ends of this outer row of fine chromic catgut sutures are threaded in a needle and passed through omentum.

in breadth, presents. On the posterior surface is the greatly dilated end of the common duct, about 1.5 cm. in diameter. Near it is the pancreatic duct, which does not seem to be enlarged. The pancreatic tissue adherent to the specimen measures 3.5x3x3 cm. (Figs. 8 and 9).

*Microscopic.*—The tumor showed an adenomatous structure with some hyperplasia of the epithelial cells in certain areas but apparently no malignancy (Figs. 10 and 11). The adherent pancreatic tissue was rather hard and appeared to be infiltrated. The pancreatic tissue showed a tendency to hyperplasia but no malignancy. The tumor produced complete obstruction in the ampulla, and probably from pressure and the local hyperemia caused inflammatory reaction and hyperplasia in the adjacent portion of the pancreas.

The case is of interest as presenting a somewhat unusual condition. It may be that operation should have been undertaken in two stages, but the facts that the growth, which was thought to be cancer, was not extensive and seemed to be readily resectable; that there were around the gallbladder many adhesions which doubtless would have recurred at the second stage of the

operation; and that the patient seemed to be in excellent general condition, appeared to indicate a one-stage procedure. The presence of "white bile" showed, of course, that the hepatic function was at a very low ebb.

FIG. 8.



FIG. 9.



FIG. 10.

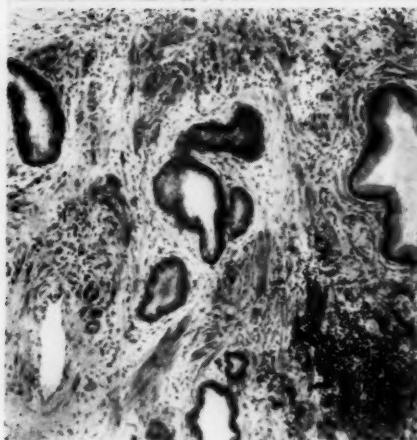


FIG. 11.



FIG. 8.—Drawing of the specimen shows attached pancreas, the greatly dilated bile duct, and adjacent to it, the pancreatic duct. At the end of the segment of duodenum is a protruding tumor.

FIG. 9.—Drawing showing tumor after the duodenum has been opened. It was firm, and fully occluded the ampulla.

FIG. 10.—Photomicrograph of the tumor shows an adenoma, or fibro-adenoma, in which there is some hyperplasia of the epithelial cells but no malignancy. ( $\times 100$ )

FIG. 11.—The central portion of the preceding figure, with hyperplasia of the cells of one of the acini, though it is not malignant. ( $\times 250$ )

The operation, as advised by Whipple, and others, for excision of the head of the pancreas and the duodenum for cancer of the pancreas or cancer of the duodenum that infiltrates the pancreas, is made possible by the physiologic finding that the presence of pancreatic juice in the gastro-intestinal tract is not essential to life, but that the internal secretions of insulin and of lipocaine are essential to life. These internal secretions appear not to be affected by suppression of the external secretion. It would seem, however, that

## TUMOR OF AMPULLA OF VATER

if the external secretion of the pancreas can be preserved without too complicated a technic, this should be done. The operation in the case reported above does not lend itself to extensive resections in which much of the pancreas must be removed. In such instances the most recent modification of Whipple's operation in which the end of the common duct is united to the jejunum after ligating the pancreatic duct would appear to be the best procedure.

### REFERENCES

- <sup>1</sup> Coffey, R. C.: Pancreato-Enterostomy and Pancreatectomy. *ANNALS OF SURGERY*, **50**, 1238, 1909.
- <sup>2</sup> Mann, Frank C., and Kawamura, Kyoichi: Duodenectomy: An Experimental Study. *Collected Papers of the Mayo Clinic*, W. B. Sanders Co., **13**, 132, May, 1922.
- <sup>3</sup> Dragstedt, Lester R., Clark, Dwight E., and Vermeulen, C.: The Significance of Lipocaic in Surgery. *ANNALS OF SURGERY*, **110**, 907, 1939.
- <sup>4</sup> Whipple, A. O., Parsons, W. B., and Mullins, C. R.: Treatment of Carcinoma of the Ampulla of Vater. *ANNALS OF SURGERY*, **102**, 763, 1935.
- <sup>5</sup> Whipple, A. O.: Surgical Treatment of Carcinoma of the Ampullary Region and Head of the Pancreas. *Am. Jour. Surg.*, **40**, 250-253, 1938.
- <sup>6</sup> Whipple, A. O.: Personal communication, May 17, 1940.
- <sup>7</sup> Brunschwig, Alexander: Resection of the Head of the Pancreas and Duodenum for Carcinoma—Pancreatoduodenectomy, *Surg., Gynec., and Obstet.*, **65**, 68, 1937.
- <sup>8</sup> Baggenstoss, Archie H.: Major Duodenal Papilla: Variations of Pathologic Interest and Lesions of the Mucosa. *Arch. Path.*, **26**, 853, October, 1938.

## SECONDARY OPERATIONS ON THE BILIARY SYSTEM\*

HAROLD L. FOSS, M.D., AND JOHN C. LILLIE, M.D.

DANVILLE, PA.

FROM THE SURGICAL SERVICE OF THE GEISINGER MEMORIAL HOSPITAL, DANVILLE, PA.

WITH THE EXCEPTION of appendicitis, probably no abdominal disease requires the surgeon's attention more frequently than does cholecystitis and the various processes involving the bile ducts, pancreas and liver so frequently associated with it. In Central Pennsylvania in the general hospital with which we are associated, drawing its patients from a large and representative American population, and with all types of surgical and medical conditions being seen, the incidence of cholecystitis admissions is 2.8 per cent, while the disease constitutes 9.1 per cent of all the admissions to the Surgical Service.

One is impressed by the high incidence of cholecytic disease among our American population. It seems especially marked among our rural American housewives. Surely, it is one of the commonest conditions with which we are confronted, yet much light must be thrown upon the question of liver physiology, on the chemistry of cholesterol metabolism, and on the rôle played by infection before its etiology can be fully understood. The sedentary, unhygienic lives of its victims, characterized so commonly by overeating and obesity, no doubt are important contributing factors.

Treatment of patients suffering from diseases of the biliary tract is, therefore, one of the chief tasks of the surgeon, one which, as our knowledge of the physiology of the liver and gallbladder advances, as it has so notably during the past few years, becomes continually more engrossing. While the first cholecystostomy was performed, in 1878, by Sims, and the first cholecystectomy, in 1882, by Langenbeck, it has only been during the past 25 years that the most significant facts regarding cholecystitis have been acquired. The men of this group of my age, or thereabouts, have witnessed and even taken an active part in nearly all the important developments of our knowledge of diseases of the biliary system. It is of historic interest, that some of the most important contributions to this subject have been made at the meetings of this Association.

As William Mayo's assistant, the senior author recalls the storm created by the cholecystectomy-cholecystostomy question, then so vehemently debated, and have listened to many of the other controversies which, from time to time, have enlivened our medical meetings, down to the more recent one dealing with the problem of when to operate once confronted with the patient suffering from acute cholecystitis.

It is the accepted practice to perform, when stones are found, a cholecystectomy, and even to carry out this procedure when no calculi are present,

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

providing the gallbladder is clearly diseased. Also, it is considered as an imperative procedure to open and explore, and usually drain, the common duct if it is enlarged, or stones are felt within it, or the clinical history and laboratory information suggest the presence of calculi. Thus, surgical treatment of these lesions has become fairly standardized, and the pooling of conclusions, resulting from large clinical experiences by men of sound judgment, has contributed in reducing mortalities probably to an irreducible minimum and in achieving results as good as, possibly, they ever can be. Yet, one should not be too prophetic, for such a statement a few years hence may sound as shortsighted as does that of Lawson Tait who, 62 years ago, in reference to Marion Sims' original paper remarked, "The entire possibilities of treatment of gallstones and distended gallbladder are exhausted by Sims' paper" (quoted by Brooks and Wyatt<sup>3</sup>).

In this study, we have been particularly interested in the mechanism accounting for a continuation of symptoms once a patient has been operated upon, but who is obliged to return for a second or even third time because of symptoms similar to those for the relief of which the first operation was performed. At the same time we have been particularly desirous of discovering what possible errors of judgment or of surgical technic, especially when the first operation was performed by ourselves, might have accounted for the return of trouble, with the hope that they may in the future be avoided.

The gallbladder patients whose records form the basis of this investigation were all treated on the senior author's service, and were operated upon by him or by his assistant. Among the 2,485 patients in this series, there were 140 upon whom we were obliged to reoperate. Sixty-eight and five-tenths per cent of the patients had their first operation elsewhere, the remainder, 31.5 per cent, had previously been operated upon by us. One hundred and nineteen, or 85 per cent were females, and 21, or 15 per cent, were males. The average age at the time of the primary operation was 40, at the secondary one, 48. While all presented interesting and variable problems, yet it was the patient upon whom we had previously operated whom we studied most critically and whose pathologic states we, naturally, examined at the second operation with especial diligence and solicitude.

#### STATISTICAL STUDY

Of the 140 patients, a previously drained gallbladder was found in 74.2 per cent. Of these patients, 20.1 per cent had been previously operated upon by us and 79.9 per cent elsewhere. Of the gallbladders removed at the second operation, 58 per cent contained stones, either overlooked at the first operation or having subsequently reformed, while 41 per cent contained none. Seven were suffering from an acute empyema at the time of the second admission. Ninety-five patients had secondary operations following a primary cholecystostomy. At the operation, the gallbladder was removed in all but 11, the common duct being explored in 27 per cent. When the gallbladder was permitted to remain at the secondary operation it was only because it had

become atrophied and apparently innocuous. Of the entire series of 140 patients operated upon secondarily, 47 (34 per cent) required a choledochostomy, the drain, a T-tube, being permitted to remain in place on the average of 16 days.

Jaundice following a primary cholecystostomy was present with 49 patients, or 53 per cent of the cholecystostomy group of 95 patients. Of the 95, 24 had dilated common ducts with stones present, but in ten, although the duct was obviously enlarged, no calculi were found. In eight, although jaundice was present, the common duct appeared normal and contained no stones. Seven had an acute empyema—four with stones in the cystic duct.

Of 33 patients previously having had a cholecystectomy, 42 per cent had been operated upon elsewhere, and 58 per cent by myself.

Of the 33 patients upon whom a cholecystectomy had been performed, stones were found in the common duct in 11, or one-third of the total, while in 22, none were found. A postoperative stricture was found in six.

Fifteen patients were admitted because of chronic postoperative biliary fistulae, the sinuses having been in existence for from one month to seven years, the average duration having been 16 months. Eight of these required a cholecystectomy to correct the difficulty, while three, in addition, required drainage of the common duct. The remainder were cured by excision of the sinus with various plastic operations upon the common duct.

Of the 33 patients who had had a simple cholecystectomy and who still presented symptoms, 66.6 per cent required a choledochostomy, the remainder needing, in addition, various plastic operations upon the common duct, and one, a choledochogastrostomy.

Fourteen patients, or 10 per cent of all those having secondary operations, had marked evidences of chronic pancreatitis, as revealed by enlargement and induration of the pancreas, especially in the region of the common duct. Upon eight of these patients, a cholecystostomy had previously been performed, and on six, a cholecystectomy.

Among the entire group there was one case of carcinoma of the pancreas, one of the bile ducts, and one of the gallbladder.

Stricture of the common duct was discovered in six patients. One of these had been operated upon by us, the other five elsewhere. All had cholecystectomies at the first operation, on the average of 31 months prior to the second celiotomy.

Eleven patients had been operated upon twice before and one, three times, the latter having had the gallbladder opened and drained three times prior to her coming to us, at which time a cholecystectomy was carried out. In practically every instance, when patients had been operated upon two or more times, the final operation consisted of a cholecystectomy for the removal of a previously drained gallbladder. In 51 per cent of this group, the common duct was also explored and drained.

The average hospital postoperative days for the entire series was 21. The hospital mortality for the group was 8.6 per cent. Deducting seven patients

## SECONDARY OPERATIONS ON BILIARY SYSTEM

who were found to have inoperable lesions, carcinoma, hopeless destruction of the common duct, *etc.*, and upon whom merely an exploration was carried out, leaves a mortality for all those having secondary operations upon the gallbladder and biliary ducts of 6.4 per cent.

TABLE I	
SECONDARY OPERATIONS UPON GALLBLADDER AND BILARY DUCTS	
Number of gallbladder patients.....	2,485
Number of gallbladder patients having secondary operations.....	140

TABLE II  
PRIMARY OPERATIONS ON GALLBLADDER AND DUCTS  
(140 Patients)

Number of Previous Operations	Patients	Where Performed	
		G. M. H.	Elsewhere
One.....	129	38 (29.4%)	91 (70.5%)
Two or more.....	11	4 (36.3%)	7 (63.6%)
Total.....	140	42 ( 30% )	98 ( 70% )

TABLE III  
SEX, INCIDENCE AND AGE

Sex	
Male	Female
21 (15%)	119 (85%)
Average Age	
Primary Operation.....	Secondary Operation.....
40	48

TABLE IV  
PRIMARY OPERATIONS

	No. of Cases
Cholecystectomy.....	24
Cholecystectomy and choledochotomy.....	6
Cholecystectomy and choledochostomy.....	3
Cholecystostomy.....	95
Exploration (elsewhere), but gallbladder found normal.....	1
Multiple operations:	
Cholecystostomy (2).....	5
Cholecystostomy (3).....	1
Cholecystectomy and chronic biliary fistula.....	2
Cholecystostomy and cholecystectomy.....	1
Cholecystectomy and cholecystostomy.....	1
Cholecystostomy and choledochotomy.....	1
Total.....	140

TABLE V

PATIENTS HAVING SECONDARY OPERATIONS FOLLOWING  
PRIMARY CHOLECYSTOSTOMY

(95 Patients)

Average Period of Relief  
3.7 yearsAverage Time Interval Between 1st and 2nd Operation  
8.1 years

TABLE VI

## TIME INTERVENING BETWEEN PRIMARY CHOLECYSTOSTOMY AND SECONDARY OPERATION

(95 Patients)

	Average Duration of Symptoms	Average Time Between Operations
No relief—20%	4 years- 5 months	4 years-5 months
Those having some relief—80%	2 years-11 months	7 years-7 months

TABLE VII

## JAUNDICE FOLLOWING PRIMARY CHOLECYSTOSTOMY

(52 Patients)

## Operative Findings

	No. of Cases
Dilated common duct with stones.....	28
Dilated common duct without stones.....	10
Common duct appeared normal.....	8
Empyema.....	3
Pancreatitis with obstruction.....	2
Carcinoma of gallbladder.....	1
Total.....	52

TABLE VIII

## TYPES OF SECONDARY OPERATIONS FOLLOWING PRIMARY CHOLECYSTOSTOMY

(95 Patients)

Cholecystectomy.....	65 or 68.4%
Cholecystectomy and choledochotomy.....	4 or 4.2%
Cholecystectomy and choledochochostomy.....	15 or 15.7%
Cholecystostomy.....	4 or 4.2%
Choledochotomy.....	2 or 2.1%
Miscellaneous.....	5 or 5.2%
Exploration and biopsy.....	1
Excision of sinus.....	2
Incision and drainage, pancreatic cyst.....	1
Cholecystectomy and transduodenal choledochotomy.....	1

TABLE IX

## TIME INTERVENING BETWEEN PRIMARY CHOLECYSTECTOMY AND SECONDARY OPERATION

(33 Patients)

	Average Duration of Symptoms	Average Time Between Operations
No relief—42%.....	2 years- 4 months	2 years-4 months
Those having some relief—57%.....	2 years-10 months	4 years-3 months

## SECONDARY OPERATIONS ON BILIARY SYSTEM

TABLE X

FINDINGS AT SECONDARY OPERATIONS FOLLOWING PRIMARY CHOLECYSTECTOMY  
(33 Patients)

	No. of Cases
Stones in common duct.....	11
No stones in common duct.....	22
Common duct normal.....	6
Common duct stricture.....	6
Pancreatitis.....	6
Cirrhosis (marked hepatitis).....	3
Carcinoma of pancreas.....	1
Carcinoma of bile duct.....	1
Total.....	33

TABLE XI

PATHOLOGY OF GALLBLADDER AT TIME OF SECONDARY CHOLECYSTECTOMIES  
(82 Patients)

Chronic cholecystitis without stones.....	34 (41%)
Chronic cholecystitis with stones.....	48 (58%)
Stones present in common duct.....	11 (13%)

TABLE XII

STENOSIS OF COMMON DUCT FOLLOWING PRIMARY OPERATION  
(Six Patients)

Primary Operation	Interval Since First Operation	Where Performed	Findings at Secondary Operation
1. Cholecystectomy	17 mos.	Elsewhere	Stricture at site of ligation of cystic duct.
2. Cholecystectomy	14 mos.	Elsewhere	Fibrous stricture of common duct.
3. Cholecystectomy	1 yr.	Elsewhere	Fibrous stricture of common duct.
4. Cholecystectomy	3 yrs.	Elsewhere	Fibrous stricture of common duct.
5. Cholecystectomy	9 yrs.	Elsewhere	Dense fibrous stricture of common duct at junction with hepatic ducts.
6. (1) Cholecystectomy (2) Choledochostomy	2 mos.	G. M. H.	Cicatrix at site of former opening in common duct.

TABLE XIII

PREVIOUS MULTIPLE OPERATIONS  
(11 Patients)

Previous Operations	When	Where	Final Operation
1. (1) Cholecystostomy (2) Chronic biliary fistula	8 yrs. ago	Elsewhere	Cholecystostomy; 2 wks. later cholecystectomy and choledochostomy
2. (1) Cholecystostomy (2) Cholecystostomy	7 yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
3. (1) Cholecystostomy (2) Cholecystectomy	2 yrs. ago	Elsewhere	Choledochostomy
4. (1) Cholecystostomy (2) Choledochostomy	15 mos. ago	Elsewhere	Cholecystectomy and choledochostomy
5. (1) Cholecystostomy (2) Cholecystostomy	18 yrs. ago	Elsewhere	Choledochostomy
6. (1) Cholecystostomy (2) Cholecystostomy	9 mos. ago	G. M. H.	Cholecystectomy and choledochostomy
7. (1) Cholecystostomy (2) Cholecystostomy	1 yr. ago	G. M. H.	Choledochostomy
8. (1) Cholecystostomy (2) Cholecystostomy	11 mos. ago	G. M. H.	Cholecystectomy
9. (1) Cholecystostomy (2) Cholecystostomy	10 days later	Elsewhere	Cholecystectomy
10. (1) Cholecystostomy (2) Cholecystostomy	2 yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
11. (1) Cholecystostomy (2) Chronic biliary fistula	19 days ago	G. M. H.	Cholecystectomy and choledochostomy
12. (1) Cholecystostomy (2) Cholecystostomy	7 yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
13. (1) Cholecystostomy (2) Cholecystostomy	6½ yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
14. (1) Cholecystostomy (2) Cholecystostomy	6¼ yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
15. (1) Cholecystostomy (2) Cholecystostomy	5 yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
16. (1) Cholecystostomy (2) Cholecystostomy	2 yrs. ago	Elsewhere	Cholecystectomy and choledochostomy
17. (1) Cholecystostomy (2) Cholecystostomy	4½ yrs. ago	G. M. H.	Cholecystectomy and choledochostomy
18. (1) Cholecystostomy (2) Cholecystostomy	4 yrs. ago	G. M. H.	Cholecystectomy and choledochostomy
19. (1) Cholecystostomy (2) Cholecystostomy	4 mos. ago	Elsewhere	Cholecystectomy and choledochostomy
20. (1) Cholecystostomy (2) Chronic biliary fistula	1 mo. ago	Elsewhere	Cholecystectomy and choledochostomy
21. (1) Cholecystostomy (2) Choledochotomy	3 mos. ago	G. M. H.	Cholecystectomy and choledochostomy
	3 days ago	G. M. H.	

## FOSS AND LILLIE

Annals of Surgery  
May, 1941TABLE XIV  
SEVEN PATIENTS MERELY HAVING EXPLORATIONS

1. No. 64993 Exploration. Advanced cirrhosis of liver. *Expired.*
2. No. 58728 Exploration and biopsy. Adenocarcinoma of gallbladder.
3. No. 70226 Exploration. Fibrosis and obstruction of common duct.
4. No. 82804 Exploration and biopsy. Adenocarcinoma of biliary ducts. *Expired.*
5. No. 50034 Exploration. Complete absence of common duct. *Expired.*
6. No. 52373 Exploration. Adhesions: Stenosis of common duct.
7. No. 62181 Exploration. Fibrous stenosis of common duct. *Expired.*

TABLE XV  
JAUNDICE OCCURRED IN 24 (72.7%) PATIENTS FOLLOWING 33 PRIMARY CHOLECYSTECTOMIES

## Operative Findings

Dilated common duct with stones.....	11
Stricture of common duct.....	0
Dense adhesions around common duct.....	3
Obstruction at head of pancreas (Ca.?).....	2
Carcinoma of bile ducts.....	1
Negative findings.....	1
Total.....	24

TABLE XVI  
INCIDENCE OF PANCREATITIS  
*140 Patients (Present in 11.0%)*

Following primary cholecystostomy.....	( 8.7%)
Following primary cholecystectomy.....	(23.5%)

TABLE XVII  
DEATHS (12)  
*Total Mortality in 140 Patients (Including Explorations for Carcinoma, etc.)*  
*Mortality—8.5%*

Age	Postoperative		Operation	Final Diagnosis
	Day			
66	31		Choledochostomy	Subdiaphragmatic abscess and peritonitis
33	2		Cholecystectomy and choledochostomy	Uremia
60	1		Exploratory celiotomy	Cirrhosis of the liver
48	7		Exploratory celiotomy	Common duct obstruction, with hepatic insufficiency
57	7		Cholecystectomy and choledochotomy	Cardiac failure
46	7		Choledochostomy	Hemorrhage; shock
56	1		Cholecystectomy and choledochostomy	Shock
58	1		Choledochostomy	Suppurative cholangitis; acute hepatitis; acute toxic nephritis
51	1		Cholecystectomy	Hemorrhage; shock
63	5		Cholecystectomy and choledochostomy	Acute peritonitis; acute cholecystitis
43	9		Exploratory; biopsy	Adenocarcinoma of biliary duct
51	2		Exploratory celiotomy	Stenosis of common duct

## SECONDARY OPERATIONS ON BILIARY SYSTEM

TABLE XVIII

CAUSES OF DEATH OF PATIENTS HAVING SECONDARY OPERATIONS ON GALLBLADDER AND DUCTS

(Excluding Seven Patients upon whom merely explorations were carried out—carcinoma, etc.)  
Mortality—6.4%

Operation	Cause of Death
1. Choledochostomy	Subdiaphragmatic abscess with peritonitis
2. Cholecystectomy and choledochostomy	Uremia
3. Cholecystectomy and choledochostomy	Cardiac failure
4. Choledochostomy	Hemorrhagic shock
5. Cholecystectomy and choledochostomy	Common duct obstruction; hepatic insufficiency
6. Cholecystostomy	Suppurative cholangitis; acute hepatitis
7. Cholecystectomy	Postoperative hemorrhage
8. Cholecystectomy and choledochostomy	Acute cholangitis; acute peritonitis
9. Exploration	Adenocarcinoma of biliary ducts.

TABLE XIX

## MORTALITY

	Mortality Percentages
Hospital mortality—Total for entire series (140 patients) having secondary operations.....	8.5%
Eliminating seven explorations for inoperable carcinoma; hopeless destruction of ducts, etc., but including all patients having secondary operations upon gallbladder or ducts.....	6.4%
Mortality following 25 secondary combined cholecystectomies and choledochostomies.....	4.7%
Mortality following 66 secondary cholecystectomies.....	1.5%

Weir and Snell,<sup>22</sup> of the Mayo Clinic, attribute persistence of symptoms following cholecystectomy, to errors in diagnosis and poor selection of cases; to residues of cholecytic disease such as cholangitis, hepatitis and pancreatitis; to stricture formation in extrahepatic bile passages; and to visceromotor disturbances, such as biliary dyskinesia. In discussing errors in diagnosis at the time of the primary operation they mention, as factors most commonly overlooked, peptic ulcer, appendicitis, pylorospasm, renal lesions and tabes dorsalis. Conditions commonly simulating jaundice mentioned by these authors were intrahepatic lesions and hemolytic states giving an indirect van den Bergh reaction. Familial or congenital hyperbilirubinemia and pernicious anemia were also referred to. Next to primary diagnostic errors, the commonest cause of symptoms necessitating secondary operations were residual changes in the bile ducts, secondary hepatitis, or pancreatitis.

Obviously, overlooked common duct stone is one of the most frequent causes of postoperative symptoms, while a second, equally important factor, is persistent cholecystitis following an incomplete cholecystectomy.

Walters<sup>19</sup> has called our attention to the extremely bizarre and atypical colics, often with absence of jaundice, occurring when overlooked common duct stones are present. Walters<sup>20</sup> as Lahey<sup>15</sup> and other recent writers, has dealt exhaustively with the subject of diagnosis and treatment of postoperative stricture. Clute<sup>5</sup> recently stated that "an accurate estimate of the relative value of the various operations for the relief of this serious condition is yet difficult." As will be recalled, Walters<sup>19</sup> reported, three years ago, 51 cases of his own, and quoted Lahey's comparative study of a number of cases of stricture treated by different methods—a clinical study of the greatest interest, and one throwing much light on the relative effectiveness of a number of procedures. Most authors who have written on the subject of secondary operations for the removal of common duct stones refer to 10-50 per cent incidence of an associated pancreatitis.

Walters<sup>20</sup> presents a summary of the experience at the Mayo Clinic with secondary operations upon the bile ducts, performed for stricture. Eighty patients were operated upon, with a mortality of 12.5 per cent. Fifteen of the 80 patients (18 per cent) have died since their operations, and the remainder have been well and without evidence of gross obstruction.

Hermanson<sup>8</sup> has stated that the presence of calculi in the common duct following a cholecystectomy results from: (1) Formation of stones in the hepatic and common ducts. (2) Descent of intrahepatic stones. (3) Escape of stones from the gallbladder into the common duct at the time of the first operation. (4) Overlooking the stones at the first operation.

One of the most complete studies of the subject was presented before this Association last year, by Heyd,<sup>9</sup> a paper of unusual interest, not only for its scientific scope but for the extraordinarily complete statistical analyses it contained. On that occasion the author described 68 patients who had had a previous cholecystostomy and who had a subsequent cholecystectomy, with a mortality of 7.4 per cent, and also 39 cases of previous cholecystectomy now having a choledochostomy, with a mortality of 40 per cent. Heyd made a plea for more frequent primary exploration of the common duct.

Among 426 cases of gallbladder disease reported by Cheever,<sup>4</sup> there were 31 secondary cholecystectomies following cholecystostomies. The common duct was explored in 37 per cent of 426 operations, with calculi being found in 44 per cent in the cases of common duct exploration.

Walters and Comfort<sup>21</sup> give the incidence of common duct stones as 12.19 per cent, while Lahey<sup>14</sup> reports exploring the common duct in 44 per cent of his cases and finding stones in 18 per cent.

Cole<sup>16</sup> has informed us that 1.8 per cent of patients having had a cholecystectomy return for operation, while 24 per cent of those who have had the gallbladder merely drained, require secondary procedures. He refers to Cave's report of 86 per cent of his patients being well following cholecystectomy, while 56 per cent of a series of patients upon whom cholecystostomies had been performed were compelled to return for re-operation.

Danzis<sup>7</sup> gives a figure of 32 as the percentage of patients having had cholecystostomies who will require secondary operations.

Kunath<sup>13</sup> states that 40 per cent of patients having gallbladder drainage usually have recurrence of symptoms in from one month to three years later, and that 17 per cent required a secondary cholecystectomy. The figure is given by Judd and Priestly<sup>12</sup> as 17 per cent.

Judd and Phillips<sup>11</sup> described eight cases of acute perforation of the gallbladder occurring some years following cholecystostomy.

Heyd<sup>10</sup> found common duct stones in 80 per cent of the patients having secondary operations following cholecystectomies. He also found that the mortality risk inherent in common duct surgery is three times that of simple, uncomplicated cholecystectomy.

Beye<sup>2</sup> reported his experience with 66 patients requiring secondary operations. Of this group, 14 were reoperated upon because of "reformed" gallbladders (dilated cystic duct stumps); 11 because of injury to the major ducts; six because of common duct stones; and two because of angulation of the common duct. While several authors have referred to dilated residual cystic duct stumps following cholecystectomy, such conditions have been rarely found in the present author's experience, and are not considered as frequent causes of postoperative symptoms.

#### PREVENTION OF SECONDARY OPERATIONS

A study of patients upon whom secondary operations become necessary, leads one to conclude that the most important single factor in the prevention of later trouble is to arrive at the primary diagnosis early; to operate as soon as the diagnosis is clearly made; and, above all else, to perform a *complete* operation at the first sitting. Almost invariably, this means a cholecystectomy, with complete avoidance of injury to the hepatic and common ducts, and with routine exploration of the latter if it is dilated, if stones are palpated

within it or if the clinical history and laboratory findings in any way suggest the presence of common duct calculi. Secondary operations become necessary, usually, because a drained gallbladder has been permitted to remain; because the common duct has been seriously traumatized; or because stones in the hepatic or common ducts have been overlooked. A few have to be performed because of reformation of common duct or gallbladder stones or because of neoplastic processes, overlooked at the first sitting, or having subsequently developed.

I have not referred to roentgenographic examination carried out during exploration of the common duct. I feel it to be of value, yet possibly too cumbersome and time-consuming a procedure to be entirely or, at least, routinely practicable. Of far more importance, it seems to me, is a most thorough exploration of the ducts, using the best of the instruments which have been devised for this purpose, among which nothing quite equals Desjardin's scoop. With adequate exposure, able assistance, and appropriate armamentarium, the surgeon, in nearly every instance, should be able to assure himself that the ducts are empty, and that adequate drainage through the ampulla has been completely established. In this, he may be aided by dilating the ampulla as proposed by Cheever,<sup>4</sup> or by resorting to the use of the Bakes' dilators, the value of which has been demonstrated by Allen and Wallace.<sup>1</sup> It must be borne in mind, however, as has been pointed out by many writers, that the advantages of this procedure may be outweighed by its inherent dangers, unless it is expertly and painstakingly employed. In the early postoperative period cholangiography is of value in revealing the degree of patency of the duct and ampulla.

One is impressed by the number of instances when findings, at secondary operations, are surprisingly slight and so out of keeping with the severity of the symptoms as to leave one baffled in attempting to account for them. As an example, eight patients were deeply jaundiced and yet had no common duct stones. Also, among 33 patients upon whom a cholecystectomy had previously been performed and who suffered from typical symptoms of severe biliary colic, there were 22 whose common ducts, at the second operation, were found empty.

Cholecystitis is a continuous and progressive condition, rarely self-limiting; its gradual and inexorable progress extending with the passage of time from the gallbladder to the ducts, to the liver, and to the pancreas. A recent study made by Heyd<sup>9</sup> revealed that patients having symptoms less than two years have stones in the common duct in 2 per cent, those with symptoms two-ten years, in 9 per cent, and those with symptoms over ten years, in 16 per cent. Complications and ultimate mortality increase proportionately with the duration of the disease, its curability becoming less possible the longer the patient is permitted to suffer from it. Let our medical confreres, and the gastro-enterologists who may be prone to treat the condition with remedial measures other than surgery, take note.

**"NONCALCULOUS" CHOLECYSTITIS**

While no one will question the advisability of surgical treatment once the diagnosis has been clearly established, one cannot but look with serious question upon statistics that, from time to time, have appeared, in which a considerable proportion of the diagnoses have been "noncalculous cholecystitis" or "mild chronic cholecystitis" or perhaps simply "cholesterosis." In a number of recent contributions, these classifications have constituted from 30 to 40 per cent of the entire series reported, and while they help to render the presentation impressive and are usually associated with a praiseworthy mortality of but 1 or 2 per cent, one has difficulty in being convinced other than that many of the operations were performed because of *symptoms* rather than because of definite pathologic processes which would justify the performance of a cholecystectomy. In a recent paper relative to a series of patients having had cholecystectomies, 44 per cent were reported as having had no stones. In another recent report, in which a large collected series of cases is analyzed, 21 per cent of the patients were recorded as having merely "mild cholecystitis." In still another series of 500 cholecystectomies but 40 per cent of the patients had stones. Still in another study of a collected series of several thousand patients, operated upon by many surgeons, the percentage of those patients having no stones was 31. Years ago, W. J. Mayo<sup>16</sup> stated that, "the milder degrees of cholecystitis, when subjected to operation, will not present a high percentage of cures, and should usually be considered medical rather than surgical problems." As Barney Brooks and Wyatt,<sup>3</sup> in their fascinating historical essay, have remarked: "Whether or not disagreeable symptoms may come from an alteration in the function of the gallbladder without anatomic change and, if so, whether these symptoms can be relieved by extirpation of the gallbladder, are unsolved problems of gallbladder disease."

There have been frequent comments from internists concerning poor results following cholecystectomy. They will continue to be warranted as long as the number of operations performed on gallbladders, with but slight or no evidence of disease, remains as high as it is at present. In studying the literature of cholecystitis, one may be disturbed by a mortality figure exceeding 6 or 7 per cent. One may, also, by the same token, be logical in questioning the justification of performing the cholecystectomies when, in a given series, the author reports a mortality much under 2 per cent. Stanton<sup>18</sup> in 1932, remarked "just so far as the clinical picture of true biliary colic becomes doubtful, or the clinical picture shades over into ill-defined digestive disturbances, that many surgeons have been wont to call the symptoms of the 'precalculus' stage of cholecystitis, do the end-results of operative treatment begin to fail."

That the majority of individuals past middle life will show some pathologic change in the walls of the gallbladder, was stressed before our Association last year by Parsons,<sup>17</sup> who added that "operations performed for mild

or nonexistent gallbladder disease, or for simple physiologic disturbances will yield universally poor results." With this we are in full agreement.

One might speculate as to what would have occurred had no operation been performed, possibly assuming that a more serious process would have appeared with the passage of time and that the cholecystectomy was justified as a prophylactic measure, if for nothing else. One might even support this contention with a positive cholecystogram. We cannot, however, but be of the conviction that when confronted with a patient presenting indefinite symptoms, that, with Hamlet, "we should have grounds more relative than this," before routinely removing a gallbladder in connection with which no possible diagnosis can be made other than chronic noncalculous cholecystitis.

The patients upon whom, in the past, we have performed cholecystectomies for symptoms, and who did not have stones and whose gallbladders revealed but little other than that discernible to the microscopic eye of a sympathetic pathologist, have usually been made worse. We learned that lesson years ago. Of the last 500 patients upon whom we have performed cholecystectomies, 92.6 per cent had stones. Walters<sup>19</sup> reports the percentage at the Mayo Clinic as being approximately the same. In their 1938 series, stones were found in 80 per cent of all the patients having cholecystectomies.

In short, yet with certain well-defined reservations, we question the identity of that pathologic vagary, usually referred to as chronic, noncalculous cholecystitis. Not that the definitely diseased gallbladder containing no stones should not be removed, but that, while the patient whose gallbladder contains calculi, obviously suffers from an entity calling for its eradication, the patient having a cholecystectomy for alleged chronic noncalculous cholecystitis may prove to be the victim of too great surgical zeal rather than the beneficiary of sound surgical judgment. Under such circumstances not only may he fail to obtain any benefit from the procedure but, as is frequently the case, may be started on a career of interminable rehospitalizations for the relief of symptoms resulting from injury of the common duct. Many of the patients referred to us for secondary operations have previously had cholecystectomies for "chronic cholecystitis without stones," the present symptoms, rather than manifestations of actual disease *per se* being the sequelae of surgical operations performed for the relief of symptoms erroneously assumed to be due to pathologic processes involving the biliary system.

#### POSTOPERATIVE HERNIA

A common, extrinsic, cause of trouble following operation upon the gallbladder and biliary tract, which may appropriately be mentioned at this time, is incisional hernia. It is referred to particularly, for the reason that the author, after closing thousands of abdomens by every conceivable method, finds his present technic so satisfactory, and wound healing so incomparably better than he has been able to obtain before. For the past six months all abdominal incisions have been closed, with a single strand of continuous catgut in the peritoneum, followed by, and this is the crux of the whole

matter, a series of closely spaced interrupted sutures of No. 30 white sewing cotton, in the deep and superficial rectus sheaths. Dead spaces in the fat are obliterated by a few interrupted sutures of cotton, and the skin approximated with interrupted sutures of the same material. No stay sutures, of any kind, are ever used. There have been no postoperative herniae, no disruptions, and no sinuses, except in primarily infected cases. If the reader is skeptical let him try the method and be convinced, as he is bound to be. Just why cotton is, in all probability, one of the best suture materials available to us, although it has reposed in our wives' sewing baskets for years without our being aware of its worth, has been adequately set forth by Mead and Ochsner.<sup>23</sup>

#### CONCLUSIONS

- (1) An analysis is presented of 140 patients requiring secondary operations among 2,485 treated by the authors for biliary tract disease.
- (2) Secondary operations become necessary largely because of incomplete procedures at the time of the primary celiotomy, or to traumatism of the hepatic ducts at that time.
- (3) The number of gallbladders, containing no stones and, possibly, the site of no disease, being removed because of suggestive symptoms, is unquestionably too high, and is one of the direct causes of symptoms necessitating secondary operations for their relief.
- (4) While many patients, following cholecystectomy, may suffer from characteristic symptoms of biliary colic, secondary explorations of the biliary system may, in a large proportion, fail to reveal any process to adequately explain the symptoms.
- (5) Cholecytic disease is a constantly progressive one, readily curable in its incipiency but one prone, with the passage of time, to produce serious and often fatal complications. The longer the delay the more serious becomes the operation and the greater likelihood of secondary operations becoming necessary.
- (6) Treatment should be carried out early. It should always be surgical. To temporize with other means is dangerous and unjustifiable.
- (7) The first operation must be a complete one, one painstakingly conducted, with extirpation of the gallbladder in nearly every instance, and with the thorough removal of all stones wherever they may be.

#### REFERENCES

- <sup>1</sup> Allen, A. W., and Wallace, R. H.: Technic of Operation on the Common Bile Duct; With Special Reference to Instrumental Dilatation of the Papilla of Vater. *Am. Jour. Surg.*, **28**, 533-561, 1935.
- <sup>2</sup> Beye, H. L.: Conditions Necessitating Surgery Following Cholecystectomy. *Surg., Gynec., and Obstet.*, **62**, 191-202, 1936.
- <sup>3</sup> Brooks, Barney, and Wyatt, Thomas E.: Surgery of the Gallbladder. *ANNALS OF SURGERY*, **109**, 334-350, 1939.
- <sup>4</sup> Cheever, D.: Methods and Results in Surgical Treatment of Diseases of Biliary Passages. *New England Jour. Med.*, **213**, 463-470, 1935.

## SECONDARY OPERATIONS ON BILIARY SYSTEM

- <sup>5</sup> Clute, H. M.: Operative Procedures in Common Duct and Hepatic Duct Injuries. *New England Jour. Med.*, **206**, 47-51, 1932.
- <sup>6</sup> Cole, W. H.: Factors in Prognosis and Mortality of Gallbladder Disease. *Internat. Abstr. Surg.*, **69**, 40-46, July, 1939.
- <sup>7</sup> Danzis, M.: Analysis of 250 Cases of Gallbladder Operations. *Jour. Med. Soc. New Jersey*, **25**, 642-645, 1928.
- <sup>8</sup> Hermanson, L.: Occurrence of Common Duct Stone Following Gallbladder Operations. *New England Jour. Med.*, **211**, 806-880, 1934.
- <sup>9</sup> Heyd, Charles: Factors in Mortality in 4,000 Operations Upon the External Biliary System. *ANNALS OF SURGERY*, **111**, 820-831, 1940.
- <sup>10</sup> Heyd, Charles, Carter, R. Franklin, and Hotz, Richard: Surgery of the Biliary Tract. *Am. Jour. Surg.*, **44**, 679-687, 1939.
- <sup>11</sup> Judd, E. S., and Phillips, J. R.: Perforation of Gallbladder in Acute Cholecystitis. *ANNALS OF SURGERY*, **98**, 359-361, 1933.
- <sup>12</sup> Judd, E. S., and Priestly, J. T.: Ultimate Results from Operations on the Biliary Tract. *J.A.M.A.*, **99**, 887-891, 1932.
- <sup>13</sup> Kunath, C. A.: Treatment of Acute Cholecytic Disease. *Surg., Gynec., and Obstet.*, **65**, 79-87, 1937.
- <sup>14</sup> Lahey, F. H.: Discussion. *J.A.M.A.*, **99**, 894, 1932.
- <sup>15</sup> Lahey, F. H.: Strictures of the Common Duct and Hepatic Ducts. *ANNALS OF SURGERY*, **105**, 765-786, 1937.
- <sup>16</sup> Mayo, W. J.: Quoted by Walters and Snell, Diseases of Gallbladder and Bile Ducts. Philadelphia, W. B. Saunders Co., 1940, p. 366.
- <sup>17</sup> Parsons, Willard: The Immediate and End-Results of Cholecystectomy. *ANNALS OF SURGERY*, **111**, 831-838, 1940.
- <sup>18</sup> Stanton, E. MacD.: The Stoneless Gallbladder. *Am. Jour. Surg.*, **18**, 246-250, 1932.
- <sup>19</sup> Walters, Waltman: Recent Advances in Surgical Treatment of Lesions of Biliary Tract. *Surgery*, **3**, 786-798, 1938.
- <sup>20</sup> Walters, Waltman: Strictures and Injuries of the Bile Ducts; Study of Results of Operations in 80 Cases. *J.A.M.A.*, **113**, 200-213, 1930.
- <sup>21</sup> Walters, Waltman, and Comfort, M. W.: Difficult Problems Encountered in Surgery of the Biliary Tract. *South. Clin. North America*, **18**, 1083-1101, 1938.
- <sup>22</sup> Weir, James F., and Snell, Albert M.: Symptoms that Persist after Cholecystectomy —Their Nature and Probable Significance. *J.A.M.A.*, **105**, 1093-1098, 1935.
- <sup>23</sup> Meade, William H., and Ochsner, Alton: The Relative Value of Catgut, Silk, Linen, and Cotton as Suture Materials. *Surgery*, **7**:485-514, 1940.

## ACUTE CHOLECYSTITIS WITH PERFORATION INTO THE PERITONEAL CAVITY\*

C. R. EDWARDS, M.D., W. H. GERWIG, M.D.,  
AND  
W. L. GUYTON, M.D.  
BALTIMORE, MD.

FROM THE SURGICAL SERVICE OF THE CHURCH HOME AND INFIRMARY, AND THE UNIVERSITY HOSPITAL,  
UNIVERSITY OF MARYLAND SCHOOL OF MEDICINE, BALTIMORE, MD.

PERFORATION of the gallbladder is referred to in most text-books on surgery as a rare complication. This statement is true only if it is considered in relationship to all cases of gallbladder lesions which come to our attention. It is common knowledge that it occurs in from 1 to 2 per cent of chronic cholecystitis.

We are interested especially in the percentage of perforations found as a complication of acute cholecystitis, and herein report 21 cases which have occurred in two hospitals in Baltimore, Md.

Perforations complicating chronic cholecystitis usually lead to abscesses about the gallbladder, the infection being "walled-off" by the adjacent colon, omentum, duodenum, and liver, and frequently lead to fistulae into the colon or duodenum, and to burrowing infections in the abdominal wall or to the subphrenic space. Perforations complicating acute cholecystitis cause a diffuse biliary peritonitis which is highly toxic, and against which the peritoneum has little defensive powers. It is with the latter group, where perforation occurs into the free peritoneal cavity, that this report is concerned.

The records of two hospitals, namely, the Church Home and Infirmary, and the University Hospital, have been studied. The cases have been under several of the surgeons of the two institutions. We believe, therefore, that this report is suggestive of the actual percentage of perforations into the peritoneal cavity which might generally be anticipated.

During the years 1929 to 1939, inclusive, at the Church Home and Infirmary, there were 32,921 admissions, of which 531 were cases of gallbladder disease, or 1.6 per cent of the total. Of the 531 cases of cholecystitis, 435 were chronic, and 96 were acute. In this latter group there were eight perforations into the peritoneal cavity, or 8.33 per cent.

In the years 1934 to 1939, inclusive, at the University Hospital, there were 34,958 admissions, of which 593 were cases of cholecystitis, or 1.7 per cent. These are divided into 496 chronic and 98 acute. In the latter group there were 13 perforations into the peritoneal cavity, or 11.5 per cent.

Therefore, in the combined groups we have 194 cases of acute cholecystitis, proven either by operation or postmortem, in which perforation occurred into

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## CHOLECYSTITIS WITH PERFORATION

the peritoneal cavity in 21 patients, a percentage of 10.82. Surely, therefore, this serious complication cannot be regarded as rare.

It is conceded by surgeons in general that patients with chronic cholecystitis may have their operation deferred while being thoroughly studied and prepared, but this policy of watchful waiting cannot be applied to the acute case with any degree of safety. This observation is clearly illustrated by the fact that only six of the eight cases of the Church Home group could be operated upon, although the length of illness prior to admission was short. The other two cases were practically moribund when admitted to the hospital; they failed to respond to treatment and succumbed to the overwhelming infection and toxemia. Therefore, only 75 per cent of this group were operable. In the remaining two cases the diagnosis was confirmed by postmortem examination.

In the University Hospital group, 12 of the 13 cases were operated upon. The remaining case, a female, age 68, who had been ill less than 24 hours before admission, was unable to endure an operation. She failed to respond to treatment and succumbed less than 18 hours after admission. A postmortem examination revealed a perforation at the fundus of the gallbladder with generalized, purulent, bile-stained peritonitis.

In the Church Home group of six operated cases, there was one death, or 16.66 per cent. In the University Hospital group of 12 operated cases, there were two deaths, or 16.66 per cent. Only one of these two fatal cases came to postmortem. A male, age 59, who had suffered severe upper right quadrant pain on frequent occasions during the previous several years. He had noted continuous pain for more than 24 hours before being referred to the hospital. On admission, he was critically ill, vomiting, distended; his skin was dry, and jaundiced, and the abdominal muscles were fairly rigid throughout. Tenderness was exquisite and diffuse, and there was a mass in the upper right quadrant. On exploration, the hepatic flexure of the colon was found to be densely adherent to the gallbladder, and obstructed. A perforation of the gallbladder had occurred just lateral to its fixation to the colon. Gallstones and bile were found in the free peritoneal cavity. Upon separating the gallbladder from the colon the obstruction to the latter was immediately overcome. The gallbladder was removed. The common duct was so edematous that it could not be palpated satisfactorily, and its exploration by sounding or open operation was regarded as unwise. The patient responded fairly well until the eleventh day when his wound disrupted. This was closed, under local anesthesia, with silver wire sutures, but the patient died two days later of bronchopneumonia. A postmortem examination revealed suppuration and calculous deposits in the ducts within the liver, and one smooth, dark stone in the terminus of the common duct.

Bacteriologically, nothing new or unexpected has been noted in this series of cases. The colon bacillus has been recovered from the gallbladder in six cases, *Streptococcus fecalis* in one case; *Streptococcus nonhemolyticus*

in one case, and *Staphylococcus aureus* in one case. No growth was recorded in four cases, and no culture was made in the remaining eight cases.

The most recent case in the University Hospital group is of particular interest, because the patient had been discharged from the hospital less than three weeks, having just recovered from a ulceroglandular type of tularemia, and while in the hospital, and being treated for tularemia, had a severe attack of cholecystitis, from which she slowly recovered. She was readmitted, March 9, 1939, for acute cholecystitis. The patient was critically ill, but because of her recent experience, and because she was being held over for material needed at an exhibition clinic, the operation was postponed. She seemed to improve, and on the day of the clinic, March 15, 1939, less than one hour before the operation was to be performed, she complained of a sudden, severe pain over the entire abdomen. Upon opening her abdomen a perforation, 2 cm. in diameter, was found in the fundus of the gallbladder, with stones and bile floating in the peritoneal cavity. Bile from the gallbladder and sections of the gallbladder wall were studied in the laboratory of the State Department of Health, and in our own laboratory for any evidence of tularemia, but none was found.

No attempts have been made in these cases to find any pancreatic enzymes, and while the regurgitation of pancreatic and duodenal juices into the gallbladder is possible under some circumstances, it is inconceivable, in view of the pathology encountered in the biliary system in the cases being considered.

The leukocyte count in the majority of our cases has averaged from 18,000 to 20,000, but no other laboratory test has been of consistent value in determining the severity of the infection and inflammation. Febrile reaction and pulse rate have been quite variable. Roentgenograms have played no part in arriving at a diagnosis in these cases. The history, in all, has been so suggestive of gallbladder disease that, as usual with this type of case, it has been dependable, and we believe that roentgenograms have no place in the diagnosis of acute cholecystitis, with or without impending perforation.

What, then, should one depend upon in order to make a diagnosis? We believe that the diagnosis of an acute cholecystitis can be accurately enough approached if based upon a carefully taken history, and an equally complete physical examination.

The exquisite tenderness on the slightest pressure over the gallbladder region is indicative of peritoneal irritation, and if this same condition is noted over the entire abdomen it certainly suggests a rapidly spreading biliary peritonitis. If, following the administration of glucose and salt intravenously, the patient looks better and feels better, but shows no, or very little improvement locally on palpation of the right upper quadrant, an immediate operation is indicated.

The particular operation performed has largely been governed by circumstances. Most of the surgeons have favored cholecystectomy, but have been forced to perform a cholecystostomy or a partial resection of a gangrenous

## CHOLECYSTITIS WITH PERFORATION

gallbladder on occasion. There have been ten cholecystectomies, seven cholecystostomies, and one partial resection of the gallbladder.

Ten years ago the senior author changed his opinion regarding the advisability of waiting for the acute cholecystitis to subside, and has never regretted this change of attitude. Increasing experience with these cases justifies the present conviction that acute cholecystitis is an abdominal emergency requiring immediate surgical intervention.

### CONCLUSIONS

(1) Perforation into the free peritoneal cavity as a complication of acute cholecystitis is not rare. It has been observed in 10.82 per cent of our cases.

(2) It occurs with or without bacterial invasion of the gallbladder.

(3) It occurs with or without gallstones.

(4) It initiates a severe chemical peritonitis, which is highly toxic.

(5) Early operation is indicated.

(6) Diagnosis of perforation is difficult to make, except at operation, but the decision of when to operate must be based chiefly upon clinical observation.

**DISCUSSION.**—DR. THOMAS S. CULLEN (Baltimore, Md.): Doctor Edwards has given us a most interesting paper on cases of acute inflammation of the gallbladder in which perforation into the free abdominal cavity has taken place. Let me go a step further and briefly relate two cases in which perforation of the gallbladder occurred and in which, at the time, no operation was performed.

**Case 1.**—Church Home and Infirmary No. 2961: Mrs. H. R., age 61, a patient of Dr. James H. Preston, of Hamstead, Md., was admitted to the Church Home and Infirmary, January 29, 1909, as an emergency. Fifteen years before, she had had pain in the region of the liver and her physicians thought she was going to die.

For 48 hours before I saw her she had been complaining of pain in the region of the appendix and had had some elevation of temperature. The pain was so severe that immediate operation was undertaken. A gridiron incision was made and the appendix was removed; this, however, showed little gross pathology. The tip of the omentum was adherent to a pedunculated, calcified myoma of the uterus, 1.5 cm. in diameter. The myoma was removed.

A hand carried into the right upper abdomen revealed adhesions; consequently, we made an upper right rectus incision. Doctor Preston said: "Fifteen years ago, when the patient nearly died, I diagnosed rupture of the gallbladder but the consultants only laughed at me and said such a thing was impossible."

Lying outside of and to the right of the gallbladder, and in no way connected with it, were about eight small, faceted gallstones. I tried to pick them up with forceps but they were covered by transparent adhesions. I split the adhesions over each with a knife and shelled them out. They reminded me of glacé nuts which have a thin, smooth covering of candy. There were dense adhesions between the duodenum and the gallbladder which was everywhere intact. The gallbladder contained several stones. These were removed and the gallbladder was drained.

The patient made a satisfactory recovery and was discharged February 17, 1909.

**Case 2.**—C. H. I., No. 49279. Mrs. E. B. J., age 52, was referred to me by Dr. Thomas R. Boggs. She complained of drowsiness and headache, and of spells of in-

definite pain in the right upper abdominal quadrant. She had had attacks similar to the present illness, on and off, for the past 30 years, and had had pain in the gallbladder region accompanied by jaundice and clay-colored stools. Her worst attack occurred about three years before I saw her.

At operation, April 29, 1929, the appendix was found to be twice its natural size in its distal portion; it was removed. The edge of the gallbladder projected above the edge of the liver, and we could see a small pile of gallstones situated on the top of the viscera, but snugly bound down by adhesions. The gallbladder, which was packed full of stones, was removed (Fig. 1). The patient was discharged June 8, 1929.



FIG. 1.—Appearance of the gallbladder approximately three years after rupture, and where no operation was performed at that time.

The gallbladder projects slightly above the edge of the liver. On its surface are numerous small, very dark-colored gallstones, and lower down, on the outer surface of the gallbladder are two small stones.

On opening the gallbladder, numerous stones are seen lying on top of the viscera but held to its surface by old adhesions. They are entirely outside of the gallbladder.

The gallbladder itself is packed full of gallstones. These vary in size, some are large, others very small.

The gallbladder is somewhat sacculated.

She was readmitted to the Church Home and Infirmary November 3, 1938. The diagnosis at that time was: Arteriosclerotic heart disease; hypertensive cardiovascular disease; and hypertrophic arthritis. There were no symptoms referable to the right upper quadrant.

The patient came in to see me to-day (December 27, 1940) and looks unusually well.

In the first case, rupture of the gallbladder undoubtedly occurred 15 years before my operation; the rupture of the gallbladder in the second case probably took place three years before we operated. It is certainly remarkable what nature alone can do in some cases.

**DR. CHARLES GORDON HEYD** (New York, N. Y.): I should like to speak first on the paper of Doctor Foss. You must recognize that gallbladder disease is a continuing pathologic change, and if and when a patient reaches the point when the cystic duct, common duct, pancreas and liver are involved, it is very doubtful if any surgical procedure would render that patient symptomless. In other words, we must view the totality of symptoms and pathologic changes in gallbladder disease.

## CHOLECYSTITIS WITH PERFORATION

In a series reported before this Association last year, it was demonstrated that in 4,000 operations for gallbladder disease, 69 per cent of the patients had chronic cholecystitis, characterized by calculi, and what is of great interest is that 6 per cent of the patients had a cholecystectomy without having calculi in the gallbladder but having calculi in the common duct. In 3,240 patients in whom a cholecystectomy was performed, the common duct was explored in 7 per cent; in the 7 per cent, 238 cases, calculi were found in the common duct in 86 per cent, with a mortality of 11 per cent. Sixty-eight patients had had a previous cholecystostomy for chronic cholecystitis and returned later for a cholecystectomy, and the mortality was 7.4 per cent, or exactly double a *primary* operative mortality for cholecystectomy. These patients had a double death-hazard in the second operation, as contrasted with the first.

Exploration of the common duct, after a previous cholecystectomy, was performed in 39 patients, with a mortality of 40 per cent; of these 39 patients, 33 of the operations were performed elsewhere than at the Post-Graduate Hospital, and of the 39 patients, 32 had recurrent, or overlooked, common duct calculi, and seven had a stenosis of the common duct. In 54 per cent of the patients with cholecystostomy that could be traced and were subsequently operated upon, 77 per cent had recurrent, or overlooked, calculi.

In 574 cases of acute cholecystitis, calculi were present in the gallbladder in 89 per cent; and calculi were present in the common duct, associated with acute cholecystitis, in 17 per cent of the cases. Therefore, if these statistics represent anything, it is that the first operative intervention for disease of the gallbladder should be as thorough and as complete as possible, as secondary operations in disease of the biliary system are characterized by such a high rise in mortality rate.

Referring to the paper of Doctor Edwards: it is rather surprising to note how many excellent physicians believe that acute cholecystitis is a condition that should be left alone, and the patient will recover, except for a few occasions of accidental perforations. This assumption is not warranted by an objective survey of the statistical material in our hands. In 3,986 operations for gallbladder disease of all kinds and types, perforation was found in 3 per cent of the total number, and in 574 cases of acute cholecystitis, perforation occurred in 69, an incidence of over 12 per cent. Of these 69 cases, there was perforation with local abscess in 18, perforation with peritonitis in 46, and perforation with pancreatitis in seven. Seventy-seven per cent of all cases with perforation had a peritonitis, and 60 per cent had a diffuse peritonitis. In other words, only 23 per cent of the patients with perforation had sufficient peritoneal protection to "wall-off" the perforation in the gallbladder, with the formation of a localized abscess.

Of even more importance is the fact that if the patient, by luck and Providence, recovers from an attack of acute cholecystitis, the mortality at the time of a second operation is, in every category, a pathologic change *double* that which occurs in the *primary* operative group. The term "immediate operation" is, in my opinion, not applicable to gallbladder surgery. In our experience, patients with acute cholecystitis that were operated upon as "emergency cases," within one to six hours after admission to the hospital, had a mortality of 14 per cent. If, however, these patients were treated in the hospital for 24 hours—largely overcoming dehydration—the mortality was reduced to 7 per cent.

DR. ROBERT L. RHODES (Augusta, Ga.): Three years ago, at the Birmingham meeting, I discussed this subject. I paraphrased the old saying that the operation was a success but the patient died, by saying that with

biliary work the operation was a success but the patient continued to suffer. We might summarize some of the points by saying that in many cases careful blood chemistry studies, pre- and postoperative, would throw light. Often-times a patient with an acute gallbladder might have blood chlorides as low as 200, and if he were operated upon then, he would die. There is another group with high uric acid content, and they would certainly burn up in rapid order.

I worked out for myself the thought that the gallbladder is a mirror as to what is in the liver behind it. Doctor Foss made the point of the relationship of the gallbladder to the liver, infection getting into the liver from the gallbladder, etc. I feel that it is the other way around, that infection has got into the lymphatics of the liver, thence into those of the gallbladder, and just so badly diseased as is the gallbladder, so also is the liver behind it. Doctor Lahey, this morning, said that surgeons must learn to think and act for themselves, and that is true. The surgeon must decide. In postoperative follow-up medical men will not cooperate, and, as a consequence, I have not turned loose a gallbladder case in less than 12 months for the past 15 years. Why? Because people have forgotten how to eat! How many people live on cold drinks and sandwiches at the drug store? They have burned their "doggoned" livers out, and if we do not teach them to get off that high acid-ash diet there is sure to be a continued acidosis. As shown by Doctor Foss, a certain percentage of patients will come back, and oftentimes a second operation will not show stones or explain the trouble, but if you bear in mind the problem of metabolism and elimination, and outline a carefully balanced diet, with an abundance of fluids, you will find you have much happier results in gallbladder work.

DR. HOWARD M. CLUTE (Boston, Mass.): Doctor Foss touched briefly on the difficulties presented by strictures of the common bile duct, and I am sure we are all familiar with the complicated technical problem that these cases present. Dr. Herman E. Pearse, of Rochester, N. Y., has devised a Vitallium tube for implanting in the strictured common duct, and he has had two successful cases in which it was used. Through his courtesy, I have obtained some of these Vitallium tubes. Recently, I operated upon a woman whose common duct had been destroyed at its upper end, and connected the tiny remnant of common hepatic duct to the common duct by a Vitallium tube. Thus far she has remained perfectly well.

I wished to give you this early report on this method in the hope that this new procedure of Doctor Pearse's may prove as useful to some of you as it has to me, in these very trying strictures of the common duct.

DR. GEORGE H. BUNCH (Columbia, S. C.): In discussion of Doctor Edwards' paper, I would like to say that infection, obstruction and change in chemical composition of bile from metabolic dysfunction are the three most common causes of cholecystitis and stone formation. By preventing stasis, better muscular development and the necessity for doing physical work are material factors in the comparatively small incidence of gallbladder disease in males as compared to females. This also explains the low incidence of gallbladder disease in the Negress.

Orthopedic immobilization, by limiting abdominal movement, may induce bile stasis to a superlative degree. We wish to report two cases in which acute exacerbation of chronic gallbladder infection took place while the patients were being treated for fractured femur.

**Case 1.**—A white male of average size, age 38, who had been in a body encasement for several weeks for fracture of both femora, developed acute pain in the upper ab-

## CHOLECYSTITIS WITH PERFORATION

abdomen with fever and leukocytosis. He had previously been in good health. On the second day after onset, an exploratory celiotomy was performed through an extension of the window in the double spica. There was found an acute perforation of a gangrenous gallbladder, with extravasation of bile into the free peritoneal cavity, and a single non-faceted stone, the size of an acorn, extruded from the gallbladder. The gallbladder was removed, the bile mopped out of the abdomen, and the wound closed, with drainage. The body encasement was not disturbed. He recovered.

**Case 2.**—An obese white female age 60, while confined to bed with her leg immobilized in a Thomas splint, developed an acute infection of the gallbladder. At celiotomy the gallbladder, containing faceted stones, was found to be gangrenous but not ruptured. She recovered after cholecystectomy.

DR. FRANK H. LAHEY (Boston, Mass.): There are two points I would like to make. I sent telegrams to two patients who had had strictures of the common duct, in whom I had implanted rubber tubes. One wire was sent to a man in Williamsport, Pa., who had been operated upon four years ago. His reply was that he had not been jaundiced since, and was perfectly well. Another case, operated upon two and one-half years ago, reported that he was without symptoms.

I think the important thing about the implantation of a tube is that you do not do it if there is anything else to be done. There are certain selected cases in which implantation of a rubber tube, or some other type of tube, is the only thing, practically, that can be done. Those are the cases in which a stricture of the common or hepatic ducts is too long for an end-to-end anastomosis or reconstruction. On the other hand, to make implantation of a rubber tube successful, there should remain, intact, the lower part of the common duct and the sphincter of Oddi. It is important in introducing the rubber tube for permanent residence in the common and hepatic ducts that the end of the tube does not pass into the duodenum. The tube should be larger than the sphincter of Oddi so that it will remain permanently in the ducts. If it is passed through the sphincter it will eventually pass out, and stricturing of the area in which it was implanted will again occur. It is undoubtedly true that not all of the rubber tubes will prove satisfactory. The most satisfactory, in our experience, will be those cases in which tubes can be implanted above the sphincter and the sphincter maintained.

Undoubtedly, as I stated at the recent meeting of the American Surgical Association, the best management of a stricture of the common duct is better education of surgeons, particularly in the way of better exposure of the common duct, when operations upon it are conducted.

If ever there is a place where the common duct ought to be explored it is where no one wants to do it—that is in a patient with acute cholecystitis. Acute cholecystitis always means infection of the biliary tract, and often infection of long-standing. That is the type of case in which if the common duct is not explored and postoperative jaundice occurs you would like to reexplore, but because of the infection are unable to do it. I think it is sound surgery to insist that not only should the common duct be explored in non-infected gallbladders, but, particularly, always in cases with acute gallbladders. With good exposure and careful dissection, the common duct can be as well and as safely exposed and explored in a patient with an acute gallbladder as in the subacute or noninfected or chronic type of gallbladder.

DR. HAROLD L. Foss (Danville, Pa., closing): The patient who is subjected to a second operation upon the biliary system runs about twice the risk that he did at the first sitting. How important it is, therefore, to see to it that the first operation is properly and completely performed! Second-

ary operations are necessitated largely because the first was badly executed, or was performed on questionable indications. I am convinced that many gall-bladders are removed unnecessarily.

Doctors Lahey and Clute referred to the question of postoperative stenosis; we have had six patients suffering from postoperative common duct stenosis following cholecystectomies, upon whom various plastic operations had been performed. Five of these patients were operated upon, primarily, in clinics other than our own; the first operation, in each instance, being a cholecystectomy.

DR. C. R. EDWARDS (Baltimore, Md., closing): I wish to place all the responsibility in the conduct of the case upon the surgeon. The difference between the time of operation on the appendix as compared to the time of operation in acute cholecystitis is one of hours. A patient with acute cholecystitis is dehydrated and acutely ill. He should be permitted, without sedation, to rest, but with free use of glucose and salt to bring up his body fluids. He should not receive sedation because if there is any evidence of irritation the surgeon should be permitted to detect it at once. That will require from 6 to 24 hours.

Doctor Lahey's comment about the necessity for investigating the duct is worth while, but unfortunately these patients who have been permitted to have a perforation of the gallbladder with other complications than that of peritonitis, are so desperately ill that when you remove the gallbladder or drain it, if bile appears immediately it looks as if you had opened a safety valve. Of course, if there is no appearance of bile it would seem that drainage is indicated, but if there is discharge of bile it is better just to put in a drain, because if there has been involvement of the entire peritoneal cavity, one has a desperately ill patient upon whom to perform *any* operation.

## A METHOD OF HANDLING THE APPENDIX STUMP\*

ALFRED P. JONES, M.D.

ROANOKE, VA.

THE PURPOSE of this brief communication is not to discuss the general subject of appendicitis but merely to call attention to a detail of technic.

It has long been recognized that the generally accepted method of ligation and inversion of the appendix stump leaves a portion of devitalized tissue, at least potentially infected, and pocketed-off between the ligature and the purse-string suture. That the danger of abscess formation or sepsis from this cause is more theoretic than probable, is amply attested by the thousands of perfect results following the employment of this technic.

Kross,<sup>1</sup> in an experimental study, found constant necrosis distal to the ligature, with ulceration of the mucosa between ligature and purse-string in many of the animals. Ochsner and Lilly<sup>2</sup> report two cases of abscess of the cecal wall originating from a buried appendix stump. One of these cases resulted fatally, the other recovered.

With the idea of eliminating this dead space and its contained devitalized tissue, a number of surgeons have advocated simple ligation of the stump without inversion (de Martel F. Bull,<sup>3</sup> C. W. Mayo,<sup>4</sup> and J. S. Horsley<sup>5</sup>). This procedure, however, is open to criticism on the following grounds: (1) Insecurity. Hilarowicz,<sup>6</sup> Ochsner,<sup>2</sup> and Edebohls<sup>7</sup> have reported cases in which the ligature "blew-off," with resultant peritonitis and death. (2) The formation of adhesions to the exposed stump (Torek,<sup>8</sup> and Willis<sup>9</sup>).

In an attempt to find a method which would avoid both of these disadvantages, the first suggestion was that the unligated stump be inverted, but this carried with it the obvious danger of peritoneal soiling while the procedure was being carried out.

Next, the use of the cautery to amputate the appendix was advocated by Kelly and Hurdon,<sup>10</sup> and more recently by Ochsner.<sup>2</sup> The use of the cautery has the double advantage in that it effectually sterilizes the exposed mucosa and at the same time seals off the stump, which may then be inverted without ligation. This technic would seem, then, to provide the answer to these two problems.

It so happens, however, that some of the more popular gases used for anesthesia—for instance, ethylene, nitrous-oxide, oxygen-ether and cyclopropane—are explosive and, therefore, render the use of cautery unwise, if not positively dangerous, while they are being employed. As we have used ethylene with great satisfaction for a number of years, and did not wish to abandon it, the following method was devised.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

Because of the simplicity of the procedure it is probable that it has been previously described, but if so, the report has not come to my attention.

FIG. 1.

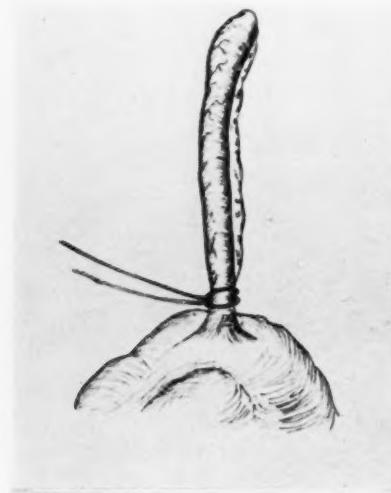


FIG. 2.

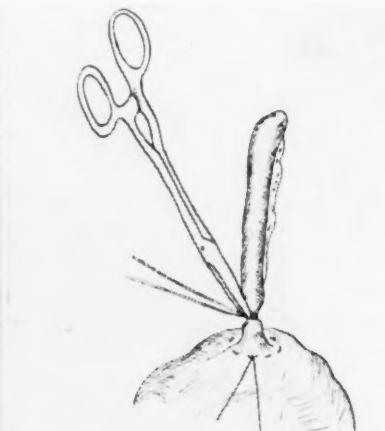


FIG. 3.

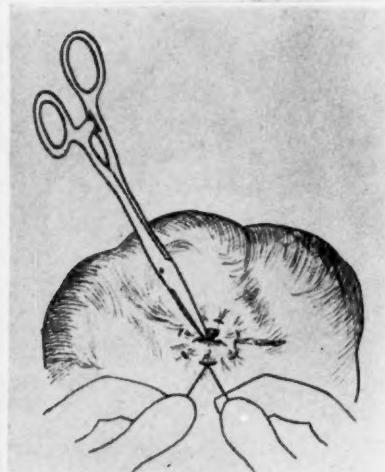


FIG. 4.

FIG. 1.—Showing application of the loop-ligature.

FIG. 2.—Showing the loop-ligature drawn firmly about the crushed area of the appendix and the application of the tip of a clamp to maintain the compression; also the introduction of the purse-string suture.

FIG. 3.—Showing the ablation of the appendix.

FIG. 4.—Showing the continued application of the clamp, until the stump is inverted by the purse-string suture.

The technic of Lenander, as illustrated in Kelly and Hurdon's<sup>11</sup> "The Veriform Appendix," shows a temporary loop of suture material being used instead of a ligature for the appendix stump, this loop being removed before the stump is inverted. Obviously, the removal of the loop permitted the possibility of leakage. The method was, therefore, modified as follows:

## TREATMENT OF APPENDIX STUMP

*Technic of Inversion of the Appendix Stump.*—After turning back a cuff of peritoneum, the base of the appendix is crushed with a Kocher clamp and a loop of zero plain catgut is drawn firmly around the crushed area (Fig. 1).

Both strands of the ligature are caught with a straight hemostat as near the tip of the clamp as possible (Fig. 2). Pressure on the clamp, exerted against pull on the double strand of catgut, makes the loop as snug as desired. The purse string-suture of fine black silk is then placed, particular care being taken to encircle the branch of the appendix artery which is frequently found in the wall of the stump (Ochsner<sup>2</sup>) (Fig. 3).

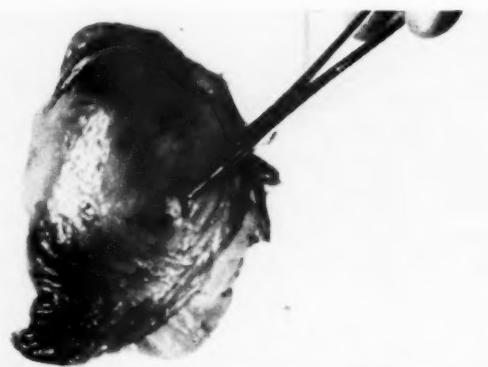


FIG. 5.—Photograph of inside of a cadaver's cecum showing the inverted appendix stump to be open.

After suitable protection with moist sponges, the appendix is clamped off just distal to the loop, amputated with a knife (Fig. 3), and the stump carbonized and neutralized with alcohol. The double strand of catgut is then cut flush with the jaws of the hemostat and the stump inverted through the purse-string suture.

Only then is the clamp released and the purse-string drawn tight (Fig. 4). A reinforcing mattress suture of fine black silk is placed, the inverted stump gently pressed between thumb and forefinger to open it up, and the stump of the meso-appendix brought up and used to cover the suture line.

Pathologic Condition	No. of Cases
Acute . . . . .	50
Acute, with gangrene . . . . .	13
Acute, with gangrene and perforation . . . . .	7
Interval . . . . .	15
Incidental to pelvic operation . . . . .	41
Total . . . . .	126
Deaths . . . . .	0

Firm and positive control of the appendix stump is provided by the clamp so that possible contamination of the wound edges is eliminated.

It would seem obvious that the free, short, loop would promptly release the inverted stump, but in order to demonstrate this beyond doubt, the technic

was employed on a cadaver. Figure 5 shows the appearance of the inverted stump from the inside of the cecum. It is apparent that the stump is open.

During the past 11 months this technic has been employed by the author in 126 cases; it was found applicable in each of the varieties encountered. There was no mortality in this series (Table I).

#### CONCLUSION

Inversion of the appendix stump by means of a loop rather than a ligature is advocated.

#### REFERENCES

- <sup>1</sup> Kross: Arch. Surg., **39**, 1016, 1930.
- <sup>2</sup> Ochsner and Lilly: Surgery, **2**, 532, 1937.
- <sup>3</sup> de Martel, F.: Bull. et mém. Soc. de chir. de Paris, **46**, 1438, 1920.
- <sup>4</sup> Mayo, C. W.: Southwest Med., **18**, 397, 1934.
- <sup>5</sup> Horsley, J. S.: Operative Surgery, St. Louis, The C. V. Mosby Co., 1924.
- <sup>6</sup> Hilarowicz: Zentralbl. f. Chir., **59**, 2407, 1932.
- <sup>7</sup> Edebohls, Geo. M.: Ann. Med. Sci., **109**, 650, 1895.
- <sup>8</sup> Torek: Quoted by Ochsner.<sup>2</sup>
- <sup>9</sup> Willis, Murat: ANNALS OF SURGERY, **48**, 74, 1908.
- <sup>10</sup> Kelly and Hurdon: W. B. Saunders & Co., 1905, p. 572.
- <sup>11</sup> *Idem*; *ibid.*: p. 575.

**DISCUSSION.**—DR. J. SHELTON HORSLEY (Richmond, Va.): There are certain biologic principles that should underlie all surgical operations, though they may not superficially appear to be mechanically admirable. One of the objections raised to the simple ligation of the stump of the appendix is that the ligature might "blow-off." Properly applied ligatures hold, and a ligature on the stump of the appendix is more easily applied and should hold better than a ligature on a blood vessel; there is less tension in the cecum than there is in an artery.

While, as a rule, it is well to approximate peritoneal surfaces, there are distinct exceptions. Polypi from the stomach or rectum are frequently removed from the lumen, and the pedicle is tied or sutured from within. Dr. B. C. Willis, in a paper read before this Association some years ago, showed that in intestinal wounds made by birdshot the patient was more likely to survive if the wounds were not sutured than if an extensive operation was performed and the wounds were sutured. The mucosa prolapses into these small wounds and closes the opening.

A ligature applied to the base of the appendix should be placed *without* first crushing the base of the appendix. In this way the mucosa has a minimum amount of trauma and merely rolls back.

DR. H. E. ROBERTSON, pathologist of the Mayo Clinic, has reported that in every case in which the appendix has been removed and the stump inverted, as an incidental procedure to another surgical operation, and the patient has died from the major procedure, necropsy has always shown that there is a pocket of pus within this cavity of the buried appendix stump. Usually, of course, this ruptures into the bowel—but why create a condition in which we must depend solely on Providence? When the stump of the appendix is buried, a closed cavity is created, within which is necrotic material—the stump of the appendix; and a foreign body—the ligature; and, to make bad matters worse, the nutrition to this pocket is partly cut off by the purse-string suture!

## TREATMENT OF APPENDIX STUMP

Since January 1, 1931, to October 1, 1940, at St. Elizabeth's Hospital, we have performed 1,142 appendicectomies, in which the appendix was the sole or the main lesion. This does not include appendices removed incidentally in the course of other operations. There were, in this series, 736 cases of acute appendicitis without perforation; 95 cases with perforation and local peritonitis; and 42 cases with spreading peritonitis. There has been no death from primary appendiceal peritonitis. Two deaths occurred from peritonitis, in which the bowel had to be resected. Of the total number of 1,142 cases, there have been eight deaths or 0.7 per cent.

The technic that we employ has nothing original about it. We ligate the stump of the appendix and the meso-appendix; sever the meso-appendix, tie the ligature on the meso-appendix around the stump of the appendix; sever the appendix, preferably with the cautery; disinfect the stump with pure carbolic; and pass the ends of the ligature on the stump of the appendix through the adjacent peritoneum-covered fat. This is done with no idea of burying the stump, but merely to bring an additional peritoneal surface to assist in digesting the stump, and to protect against drainage in cases in which there is abscess.

## END-RESULTS IN REPAIR OF INGUINAL HERNIA BY A FASCIA-TO-FASCIA RECTUS SHEATH CLOSURE\*

WILLIAM L. ESTES, JR., M.D.

BETHLEHEM, PA.

THE CAUSES and incidence of recurrence following operations for inguinal hernia rest largely upon certain major factors: (1) The age of the patient. (2) The type of hernia—direct, indirect, sliding, or recurrent. (3) The adequacy of the tissues forming the inguinal canal to maintain repair. (4) The method and manner of operation.

The importance of the gentleness in handling tissue, careful hemostasis, sharp and clean dissection and approximation of tissues *without tension* was stressed by Halsted years ago; and experience since his day has only served to emphasize the great truth of his dicta.

The principles of the operation for inguinal hernia are those laid down independently by Bassini and Halsted in 1889. Bassini, after high ligation of the sac, transplanted the cord above the internal oblique muscle which was sutured to Poupart's ligament, and the external oblique muscle was united above the cord. Halsted's original operation was quite similar except that the cord was placed superficial to the external oblique muscle. He soon modified his procedure, leaving the cord *in situ*—suturing the cremaster also to Poupart's ligament, and overlapping the fascia of the external oblique. Both W. B. Coley and Ferguson, likewise, early advocated nontransplantation of the cord. Later variations of the operation for hernia have largely been modifications of these methods.

In 1903, it was Halsted also who suggested that not only the rectus muscle, but the rectus sheath could be used to strengthen the repair of the lower portion of the inguinal canal, and an illustration of suturing the split margin of the rectus sheath to Poupart's ligament, originally sketched by Doctor Cushing but actually drawn by Max Brodel, appears in his report.

Bloodgood also stressed the use of the rectus muscle and its sheath in the closure of certain herniae, and stated that the weakness of the conjoined tendon is a major factor in recurrence which the use of the rectus muscle or its sheath attempts to correct.

Andrews, in 1895, advocated overlapping the aponeurosis of the external oblique muscle as strengthening inguinal canal closure.

McArthur, in 1901, proposed the use of narrow strips cut from the aponeurosis of the external oblique muscle, left attached at the pubic spine as suture material for uniting the structures to be apposed.

In 1923, Seelig demonstrated that in hernial repair a fascia-to-fascia closure gave the strongest possible restoration, and, a year later, Gallie and Le-

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

## INGUINAL HERNIA

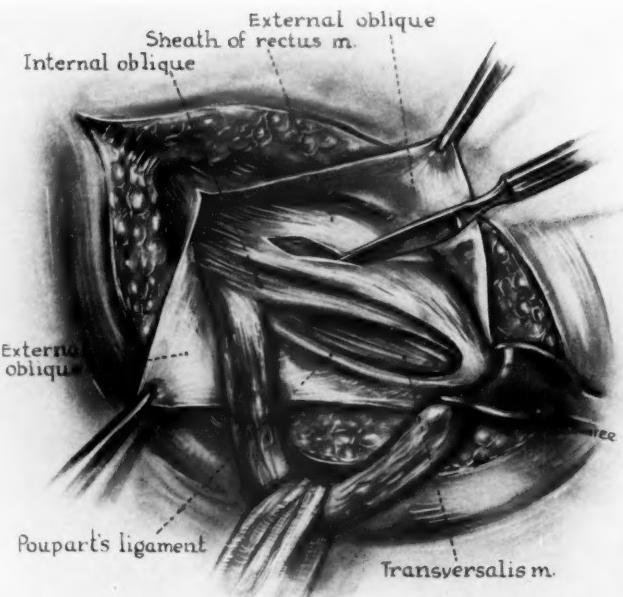


FIG. 1.—The sheath of the rectus is incised 1 cm. from the lateral margin from the level of the internal ring to the pubic spine.

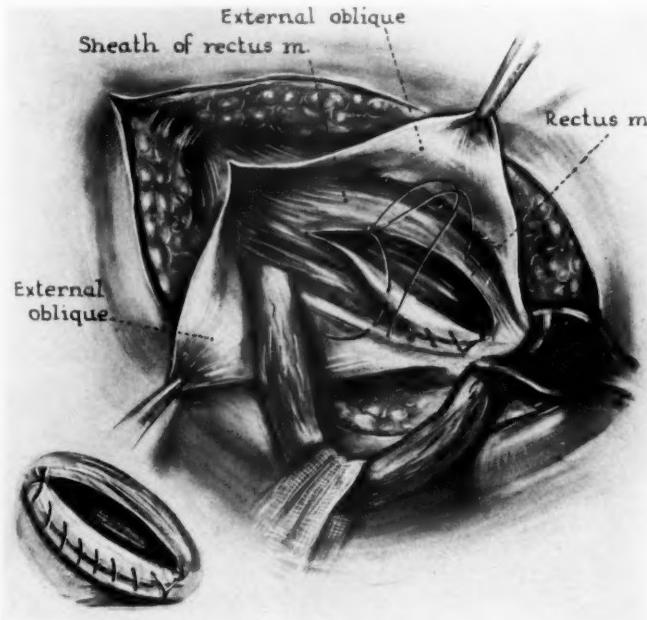


FIG. 2.—The lateral margin of the rectus sheath is sutured to Poupart's ligament.  
Insert shows completed suture line.

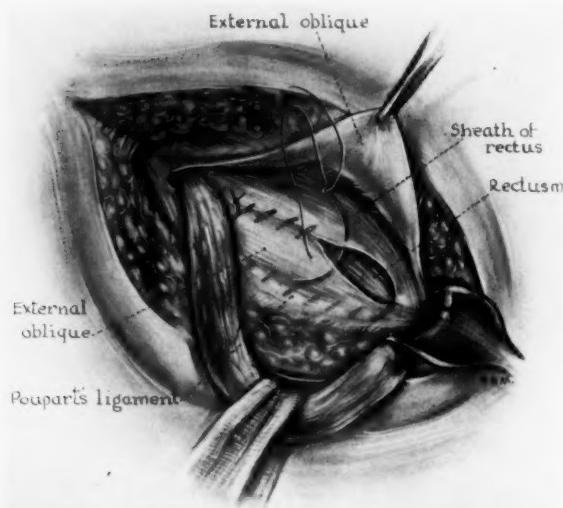


FIG. 3.—The anterior margin of the sheath of the rectus is sutured to the aponeurosis of the external oblique attached to Poupart's ligament.

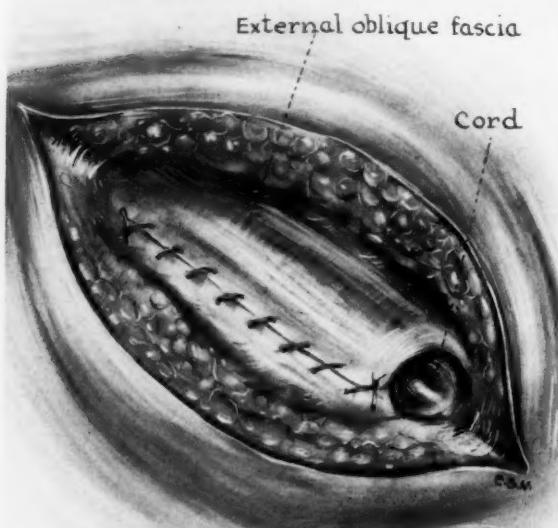


FIG. 4.—The medial portion of the aponeurosis of the external oblique is overlapped over the cord and sutured to the lateral portion of its aponeurosis close to Poupart's ligament.

Mesurier advised the use of sutures of fascia lata for the closing of difficult or large herniae.

The method of repair upon which this report is based bears largely upon the principles and procedures outlined above. It is in no sense an original operation. I first saw it employed in 1920 or 1921 by the late Dr. E. Starr Judd, but have been unable to find it illustrated in any of his published papers. Farr, and also Roberts,\* has described a very similar procedure, and, apparently, Halsted and Bloodgood occasionally used almost an identical technic except that the cord was not transplanted.

*Operative Technic.*—An incision is made about 8 to 10 cm. long, slightly oblique to Poupart's ligament and beginning at the level of the pubic spine or tubercle. The external oblique muscle is incised over the middle of the cord—down through the external ring. The ilio-inguinal nerve is identified, freed, and retracted out of the operative field. The cord is freed, the sac isolated, incised, completely freed down to its neck, which is ligated high, and the sac then resected. If the hernia is direct, the opening in the transversalis should be closed by a purse string suture. The cremaster is separated from the cord and resected and the cord is then retracted laterally. A blood vessel is sometimes encountered beneath the cord. This should be ligated close to its juncture with the deep epigastric artery and where it crosses the pubic spine and then resected. Unrecognized crushing or trauma of this vessel in the repair may be a factor in the development of postoperative emboli. The sheath of the rectus is incised or split from the level of the internal ring to the pubic spine. This incision is made about 1 cm. from the lateral edge of the rectus muscle, and is slightly convex, curving toward the internal ring and the pubic spine (Fig. 1). The lateral *inferior* margin of the rectus sheath is then sutured to Poupart's ligament (Fig. 2). The *anterior* margin of the sheath of the rectus is sutured to the aponeurosis of the external oblique muscle attached to Poupart's ligament (Fig. 3), thus making a new floor of the inguinal canal composed of two superimposed and overlapping *layers* of *fascia*. The medial portion of the aponeurosis of the external oblique muscle is overlapped over the cord and sutured to the lateral portion of its aponeurosis close to Poupart's ligament as a new roof for the inguinal canal (Fig. 4). The superficial fascia and skin are approximated separately. Either silk or catgut may be used for suture material—tension on the suture line should be sedulously avoided.

*Anesthesia.*—Local or spinal anesthesia is used exclusively, as this type of anesthesia greatly facilitates the approximation of tissues without tension.

*After-Care.*—The patients remain in bed ten days, and a spica bandage is applied for ten days more, after which no further restraint is used. Light work is permitted after six weeks; heavy work with caution after three months. Each case, however, is individualized. No restriction of occupation has been advised solely because of the operation. Many of the males under age 50 have returned to heavy labor.

\* Personal communication.

*Indications.*—As early follow-up examinations indicated a strong, firm closure without recurrence, for the last five years this operation has been employed as the operation of choice for all late adolescent and adult male patients. A simple Bassini operation has seemed quite adequate for children.

*End-Results.*—There have been 394 cases subjected to this operative procedure, of which 22 were bilateral—a total of 416 herniae; 317 indirect, 80 direct, and 19 recurrent (cases previously operated upon by other methods) (Table I). There has been no operative mortality.

TABLE I	
INGUINAL HERNIAE	
Total cases.....	394
Bilateral.....	22
	—
Total herniae.....	416
(a) Indirect.....	317
(b) Direct.....	80
(c) Recurrent.....	19
	—
	416

The patients' ages varied from 12 to 75, with 220 under 40, and 174 over 40—the greatest number being between 20 and 50.

TABLE II	
AGE INCIDENCE	
Age Groups	No. of Patients
Under 20.....	40
20 to 30.....	95
30 to 40.....	85
40 to 50.....	100
50 to 60.....	50
Over 60.....	24
	—
Total.....	394

*Follow-up Record.*—Of the 394 patients, follow-up examinations were obtained in 339, or 86 per cent (Table III). Records were unobtained in 55, or 14 per cent.

TABLE III	
FOLLOW-UP RECORD	
No. of Cases	
Cases followed 10 to 14 years.....	21
" " 5 to 10 years.....	63
" " 1 to 5 years.....	74
" " 1 year or less.....	181
	—
Total.....	339

All records are based on actual, personal reexamination of the patient except in 16 instances, in which the records of examination for employment or reemployment by large industrial firms, with competent medical staffs, were accepted. It will be noted that 181, or 53.4 per cent, were followed one year or less—all but 16 of these were observed six to 12 months after operation. It has been impossible to obtain later examinations in this group (Table III). Four of our recurrences were discovered within a year of

## INGUINAL HERNIA

the operation. Shelley states that the average postoperative time for recurrence was found to be 26 months. Erdman observed most recurrences within 12 to 18 months after operation, and believed a two-year follow-up sufficient. Gibson, acknowledging the deficiency of a less than nine-months' follow-up, found that 72.9 per cent of recurrences occurred within this period.

*Comment.*—There was but one recurrence in the group of 271 indirect herniae, or 0.4 per cent (Table IV). This occurred within six months of the operation and was found to be a direct hernia in the lower third of the inguinal canal just above Poupart's ligament, and at a point below the level of the suture line of the superimposed medial external oblique muscle, where an opening in the fascia had probably been produced by a suture near Poupart's ligament under too great tension. A modified rectus sheath operation was employed to repair the canal. This patient has remained well and solidly healed (three years).

TABLE IV  
END-RESULTS

Total Herniae.....	416	
Recurrence (postoperative).....	6 (1.4%)	

Type of Hernia	Total No. of Herniae	Follow-Up Exam.	No. of Recurrences	Percentage of Recurrence (Herniae Exam.)
Indirect.....	317	271	1	0.4%
Direct.....	80	72	2	2.77%
Recurrent.....	19	17	3	17.6%

Following the usual Bassini type of operation in larger series, the rate of recurrence in indirect herniae has been reported as 8.7 per cent (Coley); 3.15 per cent (Erdman); 1.3 per cent (Gibson); and by Taylor, following the Halsted operation, 5.6 per cent. However, when the rectus muscle or rectus sheath was employed in the repair, Erdman reported 13 cases, with no recurrences.

In the direct hernia group, one of the recurrences was in a man, age 64, with bilateral herniae. The other recurrence in the direct group, and all recurrences in patients previously operated upon, were in men overweight, with a protruding abdomen (pot-belly type), in which exception intra-abdominal tension and abdominal strain can usually be suspected or anticipated. Grace and Johnson have reported a high rate of recurrence in men over age 50 (25-34 per cent).

A recurrence rate of but 2.77 per cent in direct herniae would seem gratifying, but the number of our cases is too small to speak with finality (Table IV). Following the Bassini type of operation in direct hernia, Coley has reported 16.4 per cent recurrence; Erdman 16.6 per cent; Shelley 14.8 per cent; and Gibson 6.5 per cent; Taylor, following the Halsted operation, 18.08 per cent. However, Erdman reports a small series, in which the rectus muscle was employed in the repair, to show but 11.4 per cent recurrence; Shelley found when the rectus sheath or muscle was sutured to the inguinal ligament an increase in recurrence to 25.8 per cent. Coley feels that the direct hernia

should be individualized, and that a modified Bassini operation with a rectus sheath transplant or Gallie's fascia lata sutures should be employed. Gibson advocates the use of both the rectus muscle and sheath in the closure. Fallis stresses the proper closure of the transversalis fascia and the use of fascia lata sutures for direct herniae. Joyce's recent suggestion to use pedicled strips of the aponeurosis of the external oblique muscle, as formerly advocated by McAndrew, for suture material in the repair, would, likewise, seem to have value as an optional method.

Our recurrence rate of 17.6 per cent in recurrent herniae (Table IV), though lower than some reported statistics (23.1 per cent—Erdman), indicates that the usefulness of employing the rectus sheath for recurrent hernia is limited. The use of fascia lata sutures by the method of Gallie, or McAndrew, as revived by Joyce, or McFee's transplant of cord to femoral canal, or Wangensteen's use of a pedicled-flap of fascia lata, should have particular consideration in the operative cure of this type. Wilmouth's suggestion that irritant solutions, such as 5 per cent tannic acid may be used during and after operation to increase the fibroplasia in the wound, may have merit. It is to be remembered that Burdick, and also Coley, have reported primary wound infection to be higher when fascial sutures are used. Certainly, as Coley has so well stated, the direct hernia, and particularly the recurrent hernia, should be individualized, and that method of repair employed which best suits the character and type of tissues found.

TABLE V  
POSTOPERATIVE COMPLICATIONS

	No. of Cases
Wound infections.....	3
Atrophy of testicle.....	12 (3.34%) (Herniae examined)
Hydrocele.....	1
Total.....	16

*Complications.*—Of the three postoperative wound infections, one occurred in a man with a postoperative delirium, who tore off his dressings, got out of bed repeatedly, and later developed a recurrent hernia. The other two infections occurred in strangulated herniae, where trauma of the intestine was present, and direct contamination of the wound from the sac resulted (Table V).

The incidence of postoperative atrophy of the testicle is high (3.34 per cent) (Table V). Erdman reports but 1.5 per cent, Joyce none. There have been no instances found during the last five years—as our early follow-up revealed its occurrence. It was found to be due either to too great enthusiasm for firm and tight closure at the internal ring of the second layer of the floor of the canal; *i.e.*, the too close suture of the medial anterior sheath of the rectus to the lateral margin of the external oblique aponeurosis, or from angulation of the cord over the sharp edge of the external oblique muscle when the suture line was carried above the normal level of the internal

## INGUINAL HERNIA

ring. Closure of the internal ring, when indicated, by suture above the ring, and not carrying the line of sutures of the inguinal repair above the normal position of the internal ring has eliminated this complication.

### CONCLUSIONS

A fascia-to-fascia closure for inguinal hernia, employing the rectus sheath, has proved a satisfactory procedure, with a very low incidence of recurrence in indirect and direct herniae (0.4 and 2.77 per cent, respectively). It is particularly suited to cases not previously operated upon. Care must be taken to avoid angulation of the transplanted cord at the internal ring, or atrophy of the testicle may result. For recurrent hernia, some type of operation in which fascial sutures are employed seems preferable. Certainly, in direct and recurrent herniae the case should be individualized, and that method of repair employed which best suits the type and character of tissues found.

### REFERENCES

- <sup>1</sup> Andrews: Chicago Med. Rec., **9**, 67, 1895.
- <sup>2</sup> Bassini: Arch. f. klin. Chir., **40**, 429, 1890.
- <sup>3</sup> Bloodgood: ANNALS OF SURGERY, **70**, 81, 1919.
- <sup>4</sup> Burdick, Gillespie and Higgenbotham: ANNALS OF SURGERY, **106**, 333, 1937.
- <sup>5</sup> Coley, B. L.: ANNALS OF SURGERY, **80**, 242, 1924.
- <sup>6</sup> Coley, W. B.: Am. Jour. Surg., **2**, 1, 1927.  
*Idem*: Am. Jour. Med. Sci., **109**, 487, 1895.
- <sup>7</sup> Erdman: ANNALS OF SURGERY, **77**, 171, 1923.
- <sup>8</sup> Fallis: ANNALS OF SURGERY, **106**, 363, 1937.
- <sup>9</sup> Farr: Surg., Gynec., and Obstet., **44**, 261, 1927.
- <sup>10</sup> Ferguson, A. H.: J.A.M.A., **33**, 6, 1899.
- <sup>11</sup> Gallie: Can. Med. Jour., **13**, 469, 1923.  
*Idem*: Arch. Surg., **9**, 516, 1924.
- <sup>12</sup> Gibson: ANNALS OF SURGERY, **92**, 744, 1930.
- <sup>13</sup> Grace and Johnson: ANNALS OF SURGERY, **106**, 347, 1937.
- <sup>14</sup> Halsted, W. S.: Bull. Johns Hopkins Hosp., **14**, 208, 1903.  
*Idem*: *Ibid.*, **4**, 17, 1893.
- <sup>15</sup> Joyce: J.A.M.A., **115**, 971, 1940.
- <sup>16</sup> McArthur: J.A.M.A., **37**, 1162, 1901.  
*Idem*: *Ibid.*, **43**, 1039, 1904.
- <sup>17</sup> McFee: ANNALS OF SURGERY, **112**, 1071, 1940.
- <sup>18</sup> Seelig: Arch. Surg., **7**, 513, 1923.
- <sup>19</sup> Shelley: Arch. Surg., **41**, 747, 1940; *Ibid.*, 857.
- <sup>20</sup> Taylor: Arch. Surg., **1**, 282, 1920.
- <sup>21</sup> Wangensteen: Surg., Gynec., and Obstet., **59**, 766, 1934.
- <sup>22</sup> Wilmouth: Surg., Gynec., and Obstet., **71**, 802, 1940.

DISCUSSION.—DR. BRADLEY L. COLEY (New York, N. Y.): First, I should like to congratulate the authors of the two excellent papers on hernia, a subject of great importance. In any problem of surgery, where so many technical modifications and new procedures are advocated, it is obvious that the ideal has not yet been attained. It also indicates the failure of any one method to solve all phases of the problem.

There are many causes for recurrence after operation for inguinal hernia. Among the more important may be mentioned: Failure on the part of the

operator to identify and remove adequately a small indirect sac where the obvious finding is a direct hernia; or, overlooking the small direct or potential direct hernia while dealing with a more obvious indirect sac.

Wound infection is well-recognized as a frequent cause of recurrence, and any efforts to improve wound healing, and thus lower the infection rate, will *per se* improve the recurrence rate. At the Hospital for Ruptured and Crippled, most of us have been very much impressed by the results attendant upon the adoption, some years ago, of nonabsorbable suture material for routine hernia repair. We have satisfied ourselves that our recurrence and infection rates have been markedly lessened.

I have heard it said that the results following the use of silk are in no small measure due to the meticulous care necessary to the adoption of the *silk* technic. Some have expressed the view that if catgut were used with the same care, the results would be just as satisfactory. This view seems to me to overlook the fact that with silk there is a minimum amount of tissue reaction, and that if fine silk is used, the operator must necessarily avoid placing the sutures under tension; we believe that any hernia repair in which the sutures are under tension is apt to result in a recurrence.

I should like to emphasize Doctor Estes' statement that, in operating for hernia, one should individualize the operation, suiting it to the conditions found in each case. Hamilton Russell held that simple removal of the sac in children was sufficient. He felt that the suturing of muscle near the internal ring interfered with its normal sphincter action and was actually harmful. This sphincter action may be so affected as to prevent the contents from being extruded into a pre-existing indirect sac until some sudden strain, catching the muscles off their guard, may force the sphincter, and a protrusion results. It seems certain there is much logic in this contention.

In reporting results of hernia operations we have felt that the recurrence rate should be based upon the total number of cases followed over a period of two or more years; and it would be interesting to know whether such a follow-up of Doctor Estes' series would make any difference in his final recurrence rate. In our experience, a follow-up of less than two years is not an accurate index of the rate of recurrence.

I was much interested in Doctor Robins' operation, aiming at the reinforcement of that point in direct hernia which is notoriously the weakest, and which is the site of the majority of recurrences, *i.e.*, the space just above the crest of the pubis. His demonstration of the fact that there is a strong fascia over the bone at this point indicates that this is probably an excellent point at which to anchor sutures designed to close this defect. We have not personally employed this method, but it seems to be of definite value, and, in principle, to resemble the "high approach" operation for femoral hernia.

In closing, I should like to say a word about the applicants for employment who present themselves with a small bulge (potential direct hernia). Following a physical examination, these men are rejected by such organizations as the police and fire departments, postal service, public utilities and other industrial concerns. It has been our contention that these cases often do not warrant an operation. Now that the country is entering upon a program of national defense, with large numbers of young men being called up for examination for military service, I think it would be well to recall what Dr. William A. Downes concluded as a result of his experience in the last war, namely, that many unnecessary operations for "direct bulges" or "direct weaknesses" were performed in order to get the men in condition for military service, and that the percentage of recurrences following these operations was

## INGUINAL HERNIA

high. I would plead for the exercise of judgment in the selection of these cases for operation.

DR. HAROLD L. FOSS (Danville, Pa.): I believe that the constantly varied methods so frequently referred to in the literature, and in the many newly devised operations perennially described, indicate that the recurrence rate is too high. There is one fundamental principle in the treatment of inguinal hernia. To succeed in achieving a permanent cure we must obliterate the inguinal canal, and that means bringing some structure down and approximating it to Poupart's ligament in such a manner that it will remain there permanently. Many years ago, Kontz, of Johns Hopkins, showed in experimental animals that muscle and muscle will firmly unite, as fascia unites to fascia, but that in the former case it takes longer. Catgut does not keep these unlike tissues in approximation for a sufficiently long period, so silk has been used by us for 20 years. Recently we have changed to cotton.

About ten years ago I reported 800 operations for inguinal and femoral hernia among the coal miners of central Pennsylvania. Many of the patients operated upon for inguinal hernia on my service are also iron puddlers, and railroad men. In iron puddlers the greatest possible strain is thrown upon the abdominal muscles. These patients must be cured and must remain so. Therefore, we tried various technics over a period of many years. Our recurrences in this period have averaged 1.8 per cent. A slight modification of the original Bassini operation, using cotton, interrupted sutures, with skin clips in the skin, the operation performed under spinal anesthesia is, in my hands, the most satisfactory procedure I have found after experimenting with every known technique in the performance, now, of some 2,000 herniorrhaphies.

Doctors Estes and Robins have cast further light on the cause of recurrences and both have suggested original and ingenious methods for improving our results.

However, as to the use of fascia; I do not know of a better example in surgery where a simple procedure has been made unnecessarily hard than the one of the repair of simple inguinal by means of fascia, and yet in the hands of many (Payne, Joyce, Estes, Gallie, Robins, *et al.*) it has been, indeed, a thoroughly satisfactory technic. In large diaphragmatic repair of the average inguinal hernia, I doubt if it is ever absolutely necessary. I am one of those stubborn individuals who believes he can cure any inguinal hernia with silk or cotton that anyone can cure with fascia.

DR. WILLARD BARTLETT (St. Louis, Mo.): Just a word with regard to atrophy of the testicles, of which we hear very little, particularly with reference to bilateral herniae of any type. I had one patient with a double postoperative atrophy. That is so serious that if anyone encounters it he will probably take steps to eliminate it. So it seems that one is justified in undertaking but one operation at a time in a patient who has need for a double herniotomy.

About recurrent herniae; we heard a lot about treatment of the abdominal wall. I think most of us are prone to forget, particularly in recurring hernia, that there are two underlying causes of which suture failure is one, while internal tension is the other. If the control of function of body orifices is interfered with, there is increased tension not only abdominal but intracorporeal. If this is given due consideration along with the type of herniotomy we just heard of, I believe there would be fewer recurrent herniae. I did the eleventh operation on a man 20 years ago. It had taken a year to get him ready, and there is still no need for a twelfth. I think this is a point that needs attention.

DR. G. B. RHODES (New York, N. Y.): I would like to describe, briefly,

an operation for repair of the rectus flap, meeting with the requirements; first, fascia-to-fascia; second, complete absence of tension; and third, ability and possibility of closing the defect of which Doctor Robins has spoken. The operation is started in the usual way as for the Bassini operation. You can place behind this the weak degenerated muscle if you wish, but I do not think it has any particular value, as the muscle is weak, relaxed, atonic, and of no structural value. A triangular flap of rectus is cut. This is brought down and out, and then passed through a slit in the fibers of the external oblique. The flap can now be sewed to the shelving edge of Poupart's ligament and as far down as the pubic spine. The rest of the operation is performed as usual.

DR. FREDERIC W. BANCROFT (New York, N. Y.) : I feel that Doctor Estes has prepared for us a very satisfactory procedure in his rectus sheath closure. I have employed it as he described, but never fold in the medial portion. There is, however, one modification that might be used to advantage. It has always seemed to me that the first line of defense in the recurrent or the direct hernia is the rent in the transversalis fascia. I have been much interested in the work of Dr. Allen Fuller, of the Veterans' Hospital, in New York. As you may or may not know, the Veterans' Hospital, in New York, is the clearing hospital for all the various hospitals along the Atlantic seaboard, and it is apt to receive all the direct and recurrent herniae. Doctor Fuller believes that the bladder, when the patient is in an erect position, is one of the factors that tends to cause recurrence by hydrostatic pressure. To relieve this difficulty he dissects the bladder entirely free from the sac in direct and recurrent herniae. This leaves a raw area on the bladder, which he whip-stitches, and then passes the two ends of the suture through the rectus muscle from within outward and ties them over the rectus sheath. This procedure transplants the bladder toward the mesial line. When this procedure has been accomplished, it is very easy to isolate the transversalis fascia near the outer border of the rectus muscle. This rent in the transversalis can then be sutured to Poupart's ligament. The remainder of the procedure can then be done as described by Doctor Estes. I have performed this operation several times myself and feel it is a very satisfactory method of repair in difficult herniae. I have never seen, nor has Doctor Fuller, any disturbance in bladder function following this procedure.

DR. HAROLD FOSS (Danville, Pa.) : I would like to call attention to the work of Doctors Mead and Ochsner on the use of cotton as a suture and ligature material; work which I feel may prove an important milestone in the progress of surgery. After reading their interesting paper in the April, 1940, issue of *Surgery*, I began, rather cautiously at first, and with some misgivings, to experiment with cotton. I now find it a material well-suited to surgery, yet one that has reposed in every sewing basket for centuries, and the value of which is but little appreciated. We have used Nos. 30 and 50 plain white sewing cotton practically continuously for the past three months in the following operations (Table I) :

Including the primarily infected cases with those which were clean, we were obliged to remove cotton sutures in 2.4 per cent of all the cases, two being infected before operation was performed (Table II). I am sure that cotton will ultimately replace silk and I feel it will, in time, largely replace catgut. I fully believe cotton to be one of the very best suture and ligature materials available.

Cotton is also worth considering from an economic standpoint, this being a phase of the matter which may well intrigue our hospital superintendents. We used in our institution, in 1939, about \$1,500 worth of suture material,

## INGUINAL HERNIA

silk and catgut. On the same footage-basis, had cotton been used, \$4.20 would have supplied us with all our suture material for a year. One cent will buy 100 feet of cotton, but will buy but three inches of catgut; a mile of catgut costs \$224, and a mile of cotton 53 cents. Cotton increases in strength on boiling by about 10 per cent, and loses less than 25 per cent of its tensile strength after four weeks in the tissues, in contrast to the well-known and rapid loss of tensile strength of catgut—falling rapidly after the first 72 to 96 hours.

TABLE I  
INSTANCES IN WHICH PLAIN WHITE SEWING COTTON HAS BEEN EMPLOYED

September 1, to November 30, 1940

	No. of Cases
Operations upon gallbladder and bile ducts .....	41
Hysterectomy and other pelvic operations.....	53
Herniorrhaphy.....	24
Thyroidectomy.....	25
Mastectomy.....	8
Appendicectomy.....	28
Operations upon stomach and duodenum .....	6
Nephrectomy.....	4
Operations upon colon.....	9
Miscellaneous.....	33
Dispensary: Lacerations and minor operations..	35
Total.....	<hr/> 266

TABLE II  
INSTANCES IN WHICH COTTON SUTURES WERE LATER REMOVED

	No. of Cases
Cholecystectomy.....	1
Appendicectomy (one case*).....	2
Hysterectomy.....	1*
Bilateral saphenous ligations.....	3
Total.....	<hr/> 7 (2.4%)

\* Previously infected.

In our hands, wound healing has been better than we have ever obtained with other materials, and tissue reactions markedly less. The perfect utility of this ubiquitous, cheap, and lowly thread, in practically all types of major surgery, has proved one of the most amazing things in my surgical experience.

DR. DONALD GUTHRIE (Sayre, Pa.) : I agree with everything Doctor Foss has said about the advantages of cotton thread for ligatures and sutures.

Doctors Ochsner and Gage have made a valuable contribution in suggesting the use of cotton thread to replace silk. We have used fine silk extensively in our clinic for over five years, as we have been certain that it has many advantages over catgut, but after our experience with cotton thread for the past eight months, we believe it to be much more satisfactory in every way than silk.

DR. W. L. ESTES, JR. (Bethlehem, Pa., closing) : There are two or three points I would like to touch upon briefly. It seems to me to be a perfectly just criticism that a considerable portion of our series of cases failed to have a sufficiently long follow-up to speak with finality about the operation described. Our feeling is, therefore, that this is a preliminary rather than a final report of end-results. Secondly, I believe there would be general agreement that fascia will unite with muscle, but the point to be emphasized is that a fascia-to-fascia union is stronger. Finally, there is often found, in instances of indirect herniae, a weakness or bulging—a partial or complete breaking down

of the transversalis and the posterior wall of the inguinal canal; *i.e.*, a direct as well as indirect hernia. When this anatomic set-up is encountered we have found it expedient to suture the conjoined tendon and the margin of the internal oblique to Poupart's ligament as a preliminary step before proceeding with the fascia-to-fascia closure.

DR. CHARLES R. ROBINS (Richmond, Va., closing): I did not expect to make many conversions. When a man has spent somewhere about a generation developing a technic, he is not going to jump off to something else because a youngster comes along and makes a suggestion. However, I do believe there is some virtue in what has been suggested.

Doctor Estes has referred to eminent surgeons of the past, for development of his technic and for the modifications he has made. It was those same Masters that started me to try to find something else to cure hernia. The flap from the rectus sheath was employed by Halsted and Bloodgood, and also by Downes, and all discarded it. It did not work the way they manipulated it. Doctor Downes, in a paper presented by him before this Association, said he had given up operations upon direct hernia except in certain cases. Bloodgood made the statement that where a finger could be introduced, and particularly if two fingers could be introduced and swept around behind Poupart's ligament and the rectus muscle, he had never seen a case of this sort that was cured.

Two cases came to me with direct hernia, and, at that time, having heard such very discouraging reports from the gentlemen mentioned, I told one of the patients—"You have a form of hernia which is difficult to cure and may recur, but if you want me to operate I will." So I operated upon him. At that time Babcock, who was the first one to describe the thickened ligamentous covering of the pubic bone, had an operation which he advocated and which appealed to me because he did it with one strand of catgut. So I tried it on these two cases—and one man was so impressed by my honesty in telling him it might recur, that he came back to me when the second operation was necessary. When I asked him if he wanted me to operate upon him the second time, he replied that I was honest at any rate and for that reason he had come back to me. At the second operation I employed a patch graft, which cured him, and he remained cured until his death ten years later.

I want to leave a thought with you that may bear fruit: Doctor Estes' operation represents one of the type that really accomplishes something toward the cure of hernia. The fascia is the important thing. Nobody could criticize his results. He referred to Joyce, who read a paper before the American Medical Association, in which he reported most remarkable results. I thought they were the best I had seen, but I believe Doctor Estes is getting close to it. They are using fascia. I have noted that where surgeons are making progress they are using fascia.

When we have this muscle deficiency to which I have called attention, it can be demonstrated in operations for direct hernia, if you make a golf club incision extending over the pubic bone. You will find then there is either no conjoined tendon, or merely rudimentary fibers. My opinion is, if you have a deficiency any suture you use will be under tension. Fascia is the only tissue you can apply under tension that will hold. Up to the present time I have not had a recurrence. Of course, I do not perform many. I have a private hospital, and have no connection with industry or insurance companies that would send me many cases. The only thing is, my people believe my operation will cure them, but I would like to have somebody try it on a large number of cases, without prejudice, and see how it turns out.

## THE MANAGEMENT OF BILATERAL RENAL STONES\*

VIEWPOINT OF THE GENERAL SURGEON

J. GARLAND SHERRILL, M.D.,

AND

D. P. HALL, M.D., M.S.

LOUISVILLE, KY.

FROM THE DEPARTMENT OF SURGERY  
UNIVERSITY OF LOUISVILLE SCHOOL OF MEDICINE, LOUISVILLE, KY.

URINARY CALCULI have been of interest for many years, whether they involved the kidney, the ureter, the bladder, or the urethra. The subject has received much study, and the stones have caused much suffering. Much thought and effort has been employed for those seeking to give relief from this condition. Some very interesting experiences have come under our observation in this field.

The amount of effort spent in the solution of this subject is evident from the numerous contributions, both by lay and medical authors from Hippocrates to the present time. Hippocrates describes in detail and with accuracy the condition, and also surgical procedures, for the removal of stones from the pyonephrotic kidney (Kelly). The perusal of these writings is interesting.

A communication by Master John Arderne (1307-1380), Cambridge Reprint (unpublished), appears in "A Mirror for Surgeons," Sir D'Arcy Power; Little, Brown and Company, Boston, 1939:

"A stone impacted in the urethra causeth the patient to suffer right great pain and intolerable sorrow. It may be pushed back into the bladder by an instrument of silver or latten such as may be made in every good town by Craftsmen that maketh pins for women's heads or at the goldsmiths. Many a one have I so holpen. I have seen young men and old in which the stones have been so great that they could neither come out by the eye of the yard nor be pushed back but always abideth in the middle of the yard. And I cured them easily and quickly in this manner: First, I took the patient and laid him grovelling and then I bound the yard on both sides of the stone with linen bands, so that the stone might nowhere flee away, and with a little incision upon the stone with a lancet or with a razor I had out the stone, and after that I sewed the outer skin over the hole with a needle and thread, and then I laid on a dressing of white of an egg mixed with finely ground wheaten flour and left it for three days, and within fifteen days I had him perfectly cured."

Many of us have met a small stone in the urethra which was removable rather readily by simpler measures; had it been more difficult, Mr. Arderne's report would surely have been helpful.

We have noticed that the lay writers on this subject have, for the most part, considered it an ailment which causes suffering and is to be borne

\* Read before the Fifty-third Annual Session of the Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

with patience. Some have seemed, however, to make rather light of the ability of medical men of the early days to relieve the condition. Michel de Montaigne,\* whose autobiography, edited by Marvin Lowenthal, in 1935, we perused with much interest, says that many of his family and his friends were sufferers from stone, and those who consulted the physicians died early, while those who neglected to do so lived to about age 60. He was stricken with stone himself, and it took him quite suddenly and quite unawares. He found after a time that the condition was a good thing for him as it took his mind off some very grave and serious worries and kept it on the stone. Being a philosopher, he wrote: "What a pity I am not gifted like the man from Cicero, who, dreaming he was lying with a wench, awoke to find the stone in his sheets." He continues: "My own pains have strangely blighted my taste for wenching."

Seriously, this topic deserves the most careful consideration, and its many complications are also of particular interest. The importance of the subject was impressed upon one of us (J. G. S.) when, in 1905, during a session of the Tri-State Association of Virginia, North and South Carolina, at Greensboro, N. C., Doctor Long asked me to operate upon a physician with a tumor of very large size in the left loin. When asked for his diagnosis he said: "The deponent sayeth not." The patient had some pain during the early course of the affection, but it was never severe. He never noticed any hematuria. Rare febrile attacks were considered malaria. The mass continued to increase in size, which caused most of the patient's discomfort through the years. The diagnosis of hydronephrosis from ureteral stone was made without instruments of precision, and was based upon its slow increase in size; its location; the absence of pain on manipulation; its afebrile course, except during part of its development; and the fluctuation on bimanual palpation. Realizing no other condition which would give all these symptoms, the final clincher diagnosis was made on the table. Recovery followed removal of the kidney and the entire ureter, which was ligated at its entrance into the bladder and divided. The specimen was sent to Dr. Howard Kelly by Doctor Long, and appears in Diseases of the Kidneys, Ureters, and Bladder; Kelly and Burnam, Vol. II, 102-103, 1914.

Another very interesting case came under our care with one large stone in the right kidney pelvis and two small ones in the left. In this instance, the patient had suffered more than the one just reported and, while the condition had lasted for some time, it had forced the patient to come for relief earlier but not before the right kidney had been destroyed almost entirely by pyonephrosis. Her physician, a keen observer, recognized the gravity of her ailment and employed the means of precision before asking us to see her. There was no difficulty in making a diagnosis from the clinical symptoms and the skiagrams showed the stones clearly, while the left kidney was found present with the two small stones but performing almost the entire function (Fig. 1).

\* Houghton Mifflin Publishing Company.

## BILATERAL RENAL STONES

When such condition as the one described is met, its demand for the most accurate judgment is imperative. One cannot tell, arbitrarily, which is the better plan of treatment to pursue. In this case we had one kidney almost completely incapacitated and the other with sufficient impairment to warn us to use care in the management. Some writers upon this subject have taken the position that it is usually best to operate upon the least damaged kidney first, where both are involved with stone, and claim that

FIG. 1.

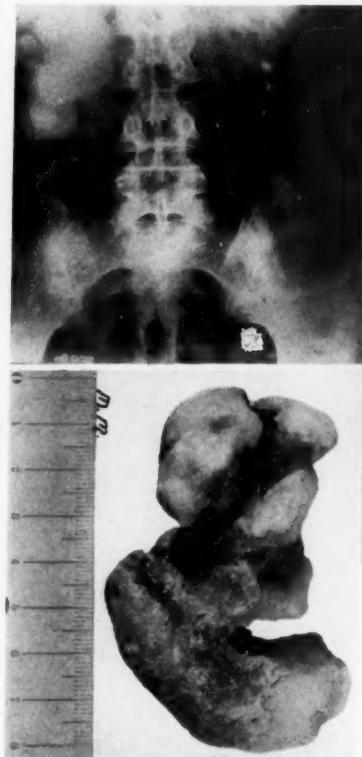


FIG. 2.



FIG. 1.—Bilateral renal stones. Right contains a very large stone. The left shows two small stones in the renal pelvis.

FIG. 2.—Pyonephrosis. Right kidney destroyed by a very large calculus.

FIG. 3.—Stone from the right kidney.

FIG. 3.

the damaged kidney will carry on to take the patient through the postoperative period and will not react as severely as will the least damaged organ.

In this case the problem was more difficult of solution because of the marked damage of the right kidney which carried the larger stone and its added infection. It was finally decided to attack the right side, even in the belief that this organ would probably have to be sacrificed. Our consultation brought this conclusion since removal of the small, and more or less "silent" stones on the left side would leave the patient without relief of her serious and painful symptoms. It also might result in failure of

the left kidney function and bring on complete anuria; therefore, it seemed that the other plan was most likely to succeed.

She was operated upon, October 7, 1922. The right kidney was exposed through a lumbar incision; a very large stone was found crowding the pelvis and impairing beyond hope the restoration of function in this kidney (Figs. 2 and 3). The immediate outcome confirmed the wisdom of the procedure. Her symptoms improved at once, and the output was 503 cc. during the first 24 hours, increasing to 562 cc. in the second 24 hours and 680 cc. on the third day. The amount arose each day until it reached 1,360 cc. on the seventh day. She was under observation for some time thereafter, and the reports were satisfactory, during which time she gained in flesh and strength, suffered no pain, no discomfort, and the urine showed no abnormal constituents.

This case emphasizes the contention so often made for early removal of stones in the renal pelvis before damage is done to the renal structures by their long-continued pressure.

This lady had not been seen for a number of years until some time ago, when we learned her present condition, which was found to be excellent. A request to be allowed to take a roentgenogram was not granted. She said: "Doctor Sherrill, those two little stones have not bothered me at all in 18 years, and I prefer not to disturb them, even to have a roentgenogram made, as I do not care to see their condition."

A very illuminating case of extremely large renal stone, with 64 minute concretions, existing through many years; destroying the left kidney; and developing both hydronephrosis and pyonephrosis, was referred by her physician, who had made the diagnosis. This was confirmed by roentgenologic and laboratory examinations, and was concurred in by us.

She was operated upon, April 13, 1940. Through a left lumbar incision, the kidney with the 64 smaller concretions, and a considerable amount of purulent urine was removed. This is a demonstration of what amount of disease can be accommodated in some cases and also shows the remarkable tissue changes in the reparative effort within the kidney tissue. It was necessary to sacrifice this kidney, but, thus, we were enabled to obtain a recovery (Figs. 4 and 5).

Many years of suffering and illness could have been avoided had she known, early in this affection, the advantage of medical advice. In the light of recent knowledge, such instances may be avoided.

It seems proper at this time to give consideration to the management of such patients who have had a successful nephrectomy. Recently, the following query was made in the Journal of the American Medical Association, 115, No. 16, October 19, 1940: "If a patient has had a nephrectomy because of massive involvement of the kidney by numerous large calcium phosphate calculi, would giving dilute hydrochloric acid, much as we do when babies have strong alkaline urines, but in much larger quantities, acidify the urine sufficiently so that a continued acid-ash diet will no longer be necessary?"

## BILATERAL RENAL STONES

Answer (in part): "After one kidney has been removed because of extreme nephrolithiasis, calculi seldom will form subsequently in the remaining kidney." We were impressed, particularly, because it called our attention to the fact that we had no recurrence in the opposite kidney following nephrectomy.

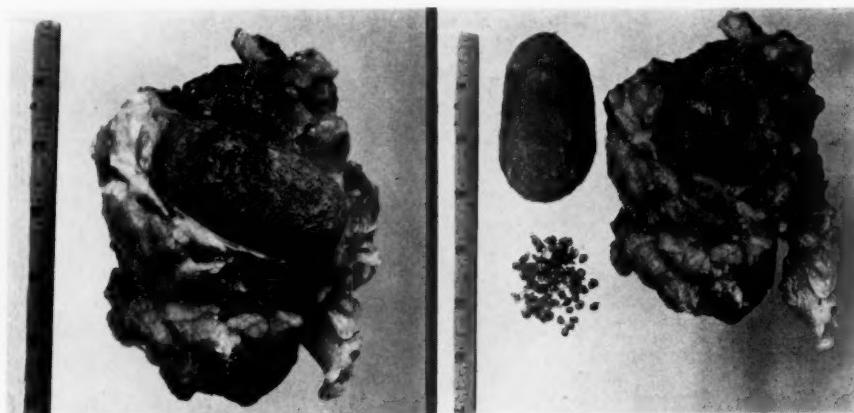


FIG. 4.—Shows a very large calculus *in situ*.

FIG. 5.—Pyonephrosis. Shows the large calculus and 64 small concretions removed from the left kidney pelvis.

Quite a number of patients have passed small stones from the kidney during the years, some with but little difficulty and others only after intraurethral manipulation. Such cases usually go to the urologist, who is able to give the necessary time and painstaking attention and detail to this department. The presence of calculi in the urinary tract of children, according to Brenner, has been frequently overlooked, despite statistical evidence to show that urolithiasis in the child is far from an insignificant entity. The incidence, evident from these statistics, parallels, to a great extent, the economic conditions under which these patients dwell.

At present, the aids to diagnosis have improved to the point that one does not attack a case of this kind without full knowledge of the affected organ, but also with the demonstration of the presence of another kidney and its functional capacity. Since then, a number of renal, ureteral, vesical and even urethral stones have come within our purview, and they have always proven interesting. There is no department of surgery in which the refinements and the accuracy in the results of studies by methods of precision are so near perfection. This does not lessen, however, the value of the accomplishments through the years by the competent general surgeons who have relieved many such patients.

Personally, we know of no department of Surgery which has given us more satisfaction or better results to the patient. It is remarkable how long a patient will carry stones in the renal pelvis, the ureter, and even the bladder without asking for relief. It is also surprising to what size such concretions reach before coming to operation. In a number of instances we

have found the entire secreting structure of the kidney lost when the patient presents for treatment (Fig. 6).

We are impressed with the efficiency with which one kidney takes on, so successfully, the function of the organ which has been thus destroyed. The presence of calculi in both renal outlets presents additional problems to those found in unilateral lesions, which are readily appreciated. The double lesion is interesting for several reasons, because in the first place bilateral stones are not of frequent occurrence. Small stone formation in the kidney of each side is not of great frequency and the occurrence of those of large

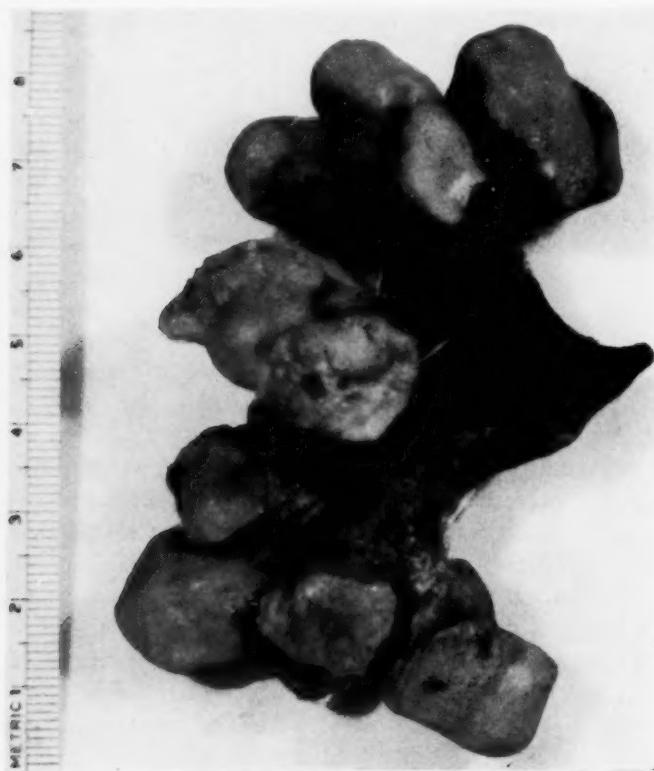


FIG. 6.—Shows a large stag-horn stone.

size is more rare. When the symptoms show on each side they are usually sufficient to force the patient to seek relief before extreme limits are reached, and this lessens the frequency with which large stones are found. Bilateral stones are of particular interest to the surgeon, because he is forced to decide the best method of treatment and clinical handling to conserve these structures and to bring relief to the patient promptly.

The usual complications which accompany the presence of calculus are met more often in cases affecting both sides. They deserve the very prompt consideration of the surgeon. Your attention is asked to a brief mention of those most frequently observed.

## BILATERAL RENAL STONES

The nervous spasm excited by the irritation of a calculus, be it large or small, single or multiple, especially when formed of oxalates, phosphates, or urates with a rough exterior, is likely to cause partial or complete interruption of secretion. This may be transient or may persist to the point of danger to life. Its occurrence appears to be more likely when the kidney structure was inflamed from some form of infection prior to the deposit of crystalline salts, and results in stone formation of size sufficient to increase the presence of colloids, bacterial clumps and blood clots in the excretory ducts and renal pelvis. Thus, we find a chain of events reacting in such a manner as to form a vicious circle.

The complications following upon these events increase in proportion to the time elapsing between the first shower of crystals (particularly oxalates) and their aggregation upon the nidus of colloid or mucoid material already thrown down in the kidney pelvis. Symptoms calling the patient's attention to something unusual, which disturbs his well-being, are increased by exercise, such as walking, playing golf, tennis, baseball, etc. The more violent the exercise and the more sweating produced thereby, results in a concentration of the urine and the deposits therefrom, as well as an increase in the pain and discomfort, because of the irritation of the sharp particles penetrating into the mucosa. Rest and a change of position with sedation gives temporary relief.

The patient continues to carry on and, as it were, becomes accustomed to a minor degree of suffering and until another sudden and severe attack, which is fortunate for his well-being, because it urges him to seek medical aid.

In a discussion of this subject one must give some thought to the causes of stone formation in the urinary tract. It is well to consider the knowledge gained from the more recent investigations into the frequency and the causative factors in the precipitation of concretions from the urine. It has long been recognized that obstruction with stasis, infection, concentration and a high degree of acidity were important in the production of concretions, particularly, if a foreign body were present. The latter may be of inorganic or of organic origin.

Recent observers conclude that renal stones may, in part, be a deficiency disease. Brenner,\* under incidence, states: "The presence of calculi in the urinary tract of children has been frequently overlooked despite statistical evidences to show that urolithiasis in the child is far from an insignificant entity." Gross says: "That most urinary calculi originate in the kidneys, from which they descend into the bladder where they gradually increase in size and ultimately produce obstruction." This statement is generally borne out by other observers.

Owing to the ease with which small fragments of concretions escape from the kidney pelvis, but few stones are found at present in the renal pelvis in children. Formerly, the number reported present, in large groups of cases, was quite large. Notably, in 1900, Assendelft, in 630 cases of vesical calculi

\* Brenner, Edward C.: *Pediatric Surgery*. Lea & Febiger, Philadelphia, 1938.

have found the entire secreting structure of the kidney lost when the patient presents for treatment (Fig. 6).

We are impressed with the efficiency with which one kidney takes on, so successfully, the function of the organ which has been thus destroyed. The presence of calculi in both renal outlets presents additional problems to those found in unilateral lesions, which are readily appreciated. The double lesion is interesting for several reasons, because in the first place bilateral stones are not of frequent occurrence. Small stone formation in the kidney of each side is not of great frequency and the occurrence of those of large

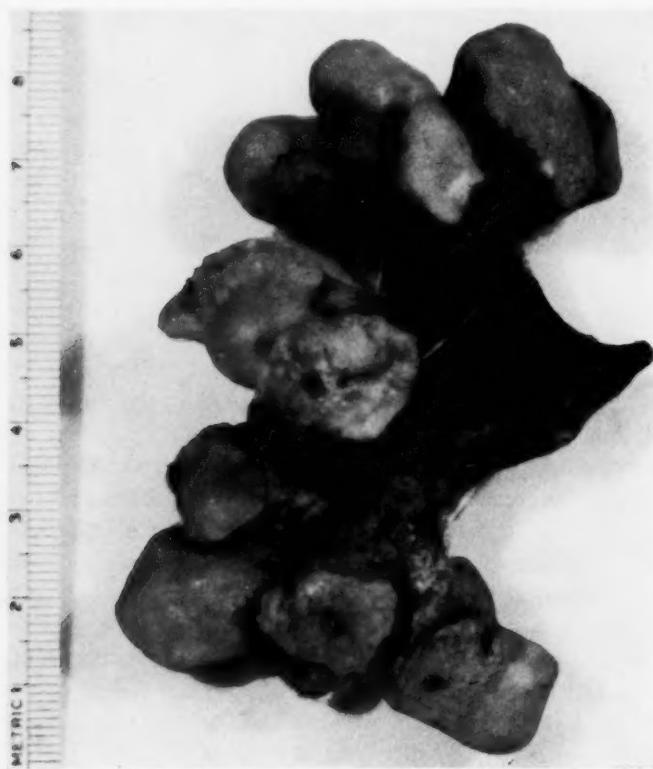


FIG. 6.—Shows a large stag-horn stone.

size is more rare. When the symptoms show on each side they are usually sufficient to force the patient to seek relief before extreme limits are reached, and this lessens the frequency with which large stones are found. Bilateral stones are of particular interest to the surgeon, because he is forced to decide the best method of treatment and clinical handling to conserve these structures and to bring relief to the patient promptly.

The usual complications which accompany the presence of calculus are met more often in cases affecting both sides. They deserve the very prompt consideration of the surgeon. Your attention is asked to a brief mention of those most frequently observed.

## BILATERAL RENAL STONES

The nervous spasm excited by the irritation of a calculus, be it large or small, single or multiple, especially when formed of oxalates, phosphates, or urates with a rough exterior, is likely to cause partial or complete interruption of secretion. This may be transient or may persist to the point of danger to life. Its occurrence appears to be more likely when the kidney structure was inflamed from some form of infection prior to the deposit of crystalline salts, and results in stone formation of size sufficient to increase the presence of colloids, bacterial clumps and blood clots in the excretory ducts and renal pelvis. Thus, we find a chain of events reacting in such a manner as to form a vicious circle.

The complications following upon these events increase in proportion to the time elapsing between the first shower of crystals (particularly oxalates) and their aggregation upon the nidus of colloid or mucoid material already thrown down in the kidney pelvis. Symptoms calling the patient's attention to something unusual, which disturbs his well-being, are increased by exercise, such as walking, playing golf, tennis, baseball, etc. The more violent the exercise and the more sweating produced thereby, results in a concentration of the urine and the deposits therefrom, as well as an increase in the pain and discomfort, because of the irritation of the sharp particles penetrating into the mucosa. Rest and a change of position with sedation gives temporary relief.

The patient continues to carry on and, as it were, becomes accustomed to a minor degree of suffering and until another sudden and severe attack, which is fortunate for his well-being, because it urges him to seek medical aid.

In a discussion of this subject one must give some thought to the causes of stone formation in the urinary tract. It is well to consider the knowledge gained from the more recent investigations into the frequency and the causative factors in the precipitation of concretions from the urine. It has long been recognized that obstruction with stasis, infection, concentration and a high degree of acidity were important in the production of concretions, particularly, if a foreign body were present. The latter may be of inorganic or of organic origin.

Recent observers conclude that renal stones may, in part, be a deficiency disease. Brenner,\* under incidence, states: "The presence of calculi in the urinary tract of children has been frequently overlooked despite statistical evidences to show that urolithiasis in the child is far from an insignificant entity." Gross says: "That most urinary calculi originate in the kidneys, from which they descend into the bladder where they gradually increase in size and ultimately produce obstruction." This statement is generally borne out by other observers.

Owing to the ease with which small fragments of concretions escape from the kidney pelvis, but few stones are found at present in the renal pelvis in children. Formerly, the number reported present, in large groups of cases, was quite large. Notably, in 1900, Assendelft, in 630 cases of vesical calculi

\* Brenner, Edward C.: *Pediatric Surgery*. Lea & Febiger, Philadelphia, 1938.

in several Russian hospitals, found 77 per cent in children under 10 years of age, and 86.5 per cent in children under 20 years of age. Monte (1881) quotes Civiali, who found, that 45 per cent of 5,000 cases of calculus occurred in children, at that time. More recently, in America, in children with a higher standard of living and a better balanced diet, the incidence is much lower, yet quite significant. Notably, Hager and Magath (1928) found 15 of 1,808 renal; seven of 813 ureteral; and 11 of 674 vesical calculi in children. In 1924, Bugbee and Wollstein, in over 4,000 pediatric postmortem examinations, found 13 with renal calculi, all associated with infections. One case occurred in an eleven-day-old baby. Theodoreescu (1928) reported 50 cases of renal calculi in 140 autopsies, the majority under six months of age. He concluded that faulty feeding, starvation, and attendant debility were important factors.

The patient must be advised to live in a manner which will lessen any deviation from the normal. In one of the cases described, the measures to obtain this result would not be recommended very highly. Her attendant gave her the usual instruction and advice as to diet, exercise and mode of life, with orders to drink large quantities of pure water free from a large proportion of alkaline ingredients, to partake freely of nonalcoholic drinks, and get plenty of rest after moderate exercise. As a fact, however, like most patients she was not impressed with any certain times to report for observation. It is likely that as she failed to remain long under his care, she did not long follow the rules given her. Nevertheless she has continued in good health for over 17 years, and has, to all outward signs, remained well. One cannot criticize her for remaining without a physician. Could we have given her a better chance or more certain security from the formation of another stone?

The progress in the study of the best diet for certain conditions has gone on apace with the progress in other lines and, although we have no records to back the statement, it seems likely that stone formation in the urinary tract is probably less frequent than in the past. A recent Manual of Urology\* devotes only 15 lines to the subject of diet, but we confess he covers the question most succinctly. Here, the statement is made that ketogenic diet has been supplanted almost altogether by the use of mandelic acid. "This is much simpler to use, obtains results more quickly, and is more efficacious." After the removal of a stone or one has been passed he says: "High vitamin-ash diets are recommended by Higgins. In alkaline urine a high vitamin A acid-ash is prescribed, but if acid, a high vitamin A alkaline-ash diet is advised." In the effort to prevent the recurrence of the gravel, elimination of infection from the urinary tract is essential. In children when symptoms of pyelitis present, which is by no means infrequent, attention must be given to check and control it, if possible, as a preventive measure against stone formation.

Tuberculosis, in our experience, is rarely followed by stone, and, at

\* LeComte, R. M.: Manual of Urology. Williams & Wilkins Co., Baltimore, 1939.

## BILATERAL RENAL STONES

most, some shadows may be seen when calcification of its products occurs. No such case is recalled in our work. The free ingestion of water, bland, and with little lime and other basic salts should be urged. Anything which obstructs the outlet should be corrected as a measure of prevention.

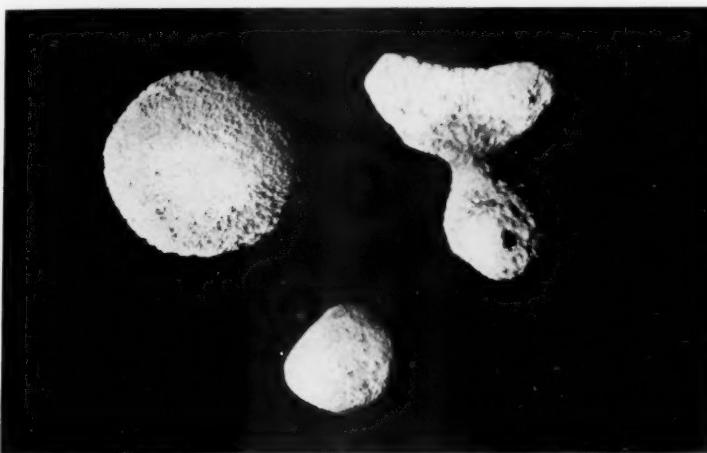


FIG. 7.—Shows the head of a pedunculated stone in a diverticulum. Two smaller stones rolled around its concave surface.

The Yearbook of Urology gives much interesting information on urography, and the comparative value of intravenous pyelography is much simpler and less painful and trying to the patient, with much less damage and trauma to the bladder and ureter.

Brief mention must be made of perirenal infections resulting from perforation into this space of the stone itself, or from the invasion of the fatty tissue by contiguity of structure. This type of complication was well covered in the literature many years ago. Most of you have handled stones in the ureter and those in the bladder, and are perhaps most familiar with these conditions. We have seen some very large and interesting stones in the bladder and prostate. Also stones have formed in the pockets of diverticula. An interesting case of such stone is shown in Figure 7, where the head of a pedunculated concretion held in the pocket had a base with a concave surface upward on which a large stone with a smaller one rolled about within the bladder, adding nothing to the patient's comfort.

**DISCUSSION.**—DR. THOMAS S. CULLEN (Baltimore, Md.): I have thoroughly enjoyed Doctor Sherrill's excellent paper. The management of bilateral renal stones has always interested me to some extent, but ever since I had bilateral stones myself, this subject has meant much more to me.

In August, 1936, Dr. Benjamin O. McCleary, one of the squarest men I have ever known, who for years had charge of the technical work in the Gynecologic-Pathologic Laboratory at John Hopkins Hospital, came up to see the quintuplets and then visited me. We had a glorious time, but two weeks later he had a cardiac attack and was gone. I came down from camp a

week earlier than usual to attend his funeral and spent the succeeding week at Mrs. Cullen's cozy country home, Morling's Chance, near Easton, Md.

The day before I was to return to work I went out among the pine trees where the men were making a path. In leaning over to pick up a file, something happened. I returned slowly to the house, went to bed and was actively nauseated all day and all night, and had much pain in the right upper abdomen. I had had acute intestinal obstruction for five days a number of years ago, as fully described by Dr. Ernest H. Gaither in the Journal of the American Medical Association, July, 1924, and Mrs. Cullen decided to bring me up to Baltimore, on the first ferry, early next morning.

The day was beautiful, and as I lay on pillows in the back of our car in the bow of the boat, looking as pale as a sheet, I picked up the Baltimore Sun and at once read a most disquieting Associated Press dispatch. At the opening of the Banting Institute in Toronto in September, 1930, the University of Toronto bestowed four honorary degrees. Davidson Black, the anthropologist, who did such wonderful work on prehistoric man in China; Charles S. Blackwell, the President of the Board of Trustees of the Toronto General Hospital; Lord Moynihan, King George's surgeon, and I were given the honorary degree of LL.D. I knew that Black was dead; Blackwell had also passed away, and the morning paper brought the news of Lord Moynihan's death. I was the last of the four, and it seemed probable that my trouble was intestinal obstruction. I certainly did some intensive thinking and was unusually subdued.

Upon my admission to the Church Home and Infirmary, my surgeon, Dr. Howard Smith, had a roentgenologic examination made at once. The discomfort was due to a stone passing down the right ureter. There was also at least one stone in the left kidney. I was given appropriate treatment and also numerous enemas. I soon developed two large strangulated hemorrhoids, which it was thought might become gangrenous.

I was given novocain and pantopon at 6:30 A.M., and the hemorrhoids were removed by Dr. Gerald Ackerman at 7 A.M. At 8 A.M. I had my breakfast, and by 10:30 was as drunk as a lord. Dr. Thomas B. Futcher was called, as some thought I was having a cerebral accident. Dean Lewis and John Finney came down to see me drunk for the first time. The next morning I was all right.

The stone in the right ureter was in no hurry to move.

In 1903, I had operated at the home of Dr. Sam Trippe, of Royal Oak, upon his nephew, Joe Chamberlain, for ruptured appendix and peritonitis. The boy did well, but three weeks later developed intestinal obstruction. He was brought about eight miles on a jerk-water railroad, then about 50 miles on the steamer, and then by ambulance from the boat over a cobblestone road to the Church Home and Infirmary, which was two miles distant. The jolting had straightened out the bowel, he had a good movement, and operation was unnecessary.

Remembering this case, I had the hospital ring up Mayor Howard W. Jackson to see whether there were any cobblestone streets remaining near the hospital. There were a couple of them. Accordingly, I rode up and down one of these streets several times hoping that the jolting would facilitate the passage of the stone. In a short time I was relieved of my discomfort and soon returned home.

During my illness I had for some reason broken off two front teeth; accordingly, I really had three sets of twins—two broken front teeth, two strangulated hemorrhoids, and at least one stone in each kidney.

The value of riding over cobblestones to jolt stones down is really only

## BILATERAL RENAL STONES

of historic interest. In most places cobblestone streets have given way to paved ones, and corduroy roads are too far removed from hospitals to be of value to weakened patients. Fortunately, my renal stones were small, and the ride relieved me of discomfort, but the stones did not pass for several weeks.

DR. HENRY D. FURNISS (New York City): I think we should thank Doctor Grant for his method of demonstrating these cases in which he has done air pyelograms. He exercised very good and proper precautions. It has great value in cases in which it is desirable to take a picture of the kidney with the patient in the erect position. He spoke of the use of air; I think carbon dioxide is safer. If you should have any kind of accident, carbon dioxide is absorbed very quickly. It is easy to use, and it can be obtained at the drug store without trouble. Dry ice is dropped in a beaker of water, and the gas that accumulates is removed with a syringe.

This method has some value but I do not think it will ever displace the contrast media. Carbon dioxide is quickly absorbed from any contact with water. In the Rubin test, if the apparatus is clamped off with the gas under pressure, there will be sufficient absorption to produce negative pressure in three or four hours.

With reference to Dr. Sherrill's paper, he has given us some excellent work. One thing he brought out is the influence of drainage. We have dilated the obstructed ureter after operation, and when infection is present, lavaging the pelvis with 0.5 per cent silver nitrate. After such treatment recurrences have been definitely less frequent.

DR. IRVIN ABELL (Louisville, Ky.): This is an extremely interesting paper on a surgical condition that offers many problems for solution. So far, the studies that have been made do not completely explain the origin of all renal calculi. A number of important, and seemingly independent factors may be responsible for disturbing the colloid-crystalloid equilibrium of the urine and initiating the mechanism of stone formation. Among these may be mentioned stasis, infection, vitamin deficiency, metabolic perversions, trauma, papillary or caliceal ulcerations, and disturbance in calcium-phosphorus metabolism. Our present knowledge does not adequately explain the formation of a pure uric acid calculus in one person, a pure oxalate calculus in another, and a triple phosphate calculus in yet another. It does not clarify the difference between the person who forms and passes but one stone and the individual who repeats and repeats. It does not elucidate the problem of the patients who, for long periods of time, eliminate phosphates, oxalates and urates in the urine without the formation of stone.

Again, the kidneys are bilateral organs, and primary stones are unilateral in approximately 75 per cent of all cases, leaving 25 per cent in which they are bilateral. In our observation, the latter may be roughly divided into two groups: One in which the stones in each kidney are of equal size; and one in which a large stone occupies one kidney, with a smaller stone in the kidney or ureter of the opposite side. When large-branched or stag-horn calculi occupy both kidneys, and the latter give no evidence of active infection, it becomes a moot question as to whether or not such patients will live longer and more comfortably without operation than with it. The inevitable injury to renal tissue in the removal of such stones, and the almost invariable recurrence, have led many to employ operative treatment only in the presence of complications. The supervention of infection, if limited to one kidney, is an indication for operation on that side; if it involves both

kidneys, the extent of renal impairment will determine for or against the advisability of operation.

When the stones are of smaller size and occupy positions accessible to removal through pyelotomy incisions, the only contraindication to operation is the presence of such renal damage as to make the prospect of regeneration a hopeless one. In the second group, characterized by a large stone in one kidney and a smaller one on the opposite side, granting the function of the side containing the smaller stone is satisfactory, the latter should be removed. The disposition of the kidney with the large calculus will depend upon function, impairment of renal tissue, quiescence and infection; if pyonephrotic, its removal will be indicated both to prevent recurrence in it and as a protection to the opposite side. It is axiomatic in the operative removal of calculi from both sides of the urinary tract, to operate upon but one side at a time, and it has been quite generally the custom to operate first on the side showing the best function, in order to conserve this property as far as possible before approaching the more badly damaged one. We have made exceptions to this rule in pyonephrosis, giving rise to fever and constitutional disturbance, and in the cases in which the calculus on one side was situated in the ureter or at the ureteropelvic junction, the active pyonephrosis demands immediate attention regardless of the better function on the opposite side, and the ureteral and ureteropelvic stones, because of their greater opportunities for causing acute obstruction and infection, had best be removed first as a precautionary measure. Again, if one kidney is causing severe pain, it should be operated upon first, regardless of whether or not it is the more damaged of the two, since pain is an indication of active disease in a kidney possessing functional value, the saving of which becomes a prime consideration. It is difficult, if not impossible, to draw hard and fast rules for the management of bilateral calculi; renal function; size, number and location of stones; infection—age and general physical condition of the patient all enter into the picture and must be evaluated in reaching a decision.

DR. LAWRENCE R. WHARTON (Baltimore, Md.): There are two points I want to bring out. One has been emphasized by Doctor Abell, about the people who have both kidneys involved with stones. I think there are exceptions to the statement he made that persons who have large stones in both kidneys live longer if they are not operated upon. In persons who have large calculi, particularly if there is infection and poor ureteral drainage, the lease on life is very short. I know this from my own experience with patients who are living after 10 or 12 years, after having many calculi removed from both kidneys.

The second point I want to make is the necessity and advisability of conservatism in all types of renal and ureteral surgery for stone. The proponents of radical surgery have advocated that the hydronephrotic or damaged kidney will not come back and should be removed if the opposite kidney is sound. I know of cases in which ureteral stones have completely obstructed the ureter, and reduced the renal function to zero. Passage of the stone was followed by complete return of function of the kidney. That refutes the contention that the hydronephrotic kidney will not come back if the opposite kidney is normal. If the kidney is capable of regeneration, an effort should be made to save it rather than take it out.

DR. OWSLEY GRANT (Louisville, Ky.): I just want to say how much I enjoyed Doctor Sherrill's paper. It is always inspiring to hear from a man who has had such an extensive experience. The things he emphasized are important, and I think the two most important are that in either bilateral or

## BILATERAL RENAL STONES

single calculi of the kidney, the stone is not a disease but a symptom. These conditions require constant treatment after they are removed. Bilateral stones present a much more complicated problem. Now as to drainage in these cases: Any case in which it is necessary to remove a stone of considerable size, it is necessary to continue this until the kidney has had an opportunity to recover. As to the question of which side to operate upon: That is a matter of dogmatic and didactic instruction. We used to be told to operate upon the bad side, and now it has come back to operating upon the good kidney—the problem depends largely on the function, and the seriousness of the condition.

I wish to thank Doctor Furniss for the suggestion as to carbon dioxide. I did not know it could be done so easily. We have had no difficulty with the air pyelogram, and have found it helps greatly in some of these complicated cases.

DR. J. GARLAND SHERRILL (Louisville, Ky., closing): When first considering this topic I did not know the extent of the undertaking; since it has led me far afield in the literature.

Doctor Grant's remarks are particularly pertinent, and I agree with what he has said. One patient, mentioned before, carried stones in the left ureter for considerably more than nine years. We did not have the instruments of precision we now have to aid in making the diagnosis, and the patient, himself a physician, did not suspect that he had any stones, but intermittent ureteral obstruction resulted in constant, gradual increase of an hydronephrosis. We must remember that a "quiet" stone may cause symptoms that resemble obstruction of the intestine and may receive treatment for that condition until the stone is discovered. Fortunately, though formed in the renal pelvis, these concretions do not usually remain there, but tend to lodge in the ureter, and there cause blocking, with resultant more or less severe pain. Why they form on one side and not on the other is not entirely clear, but it is reasonable to suppose that either spasm or organic stenosis of the ureter is an important factor. When they appear in both pelvis it must be concluded that there is a bilateral congenital obstruction on each side.

The discovery by Mandl, in Vienna, in 1925, and by Dubois, in this country, in 1926, that *osteitis fibrosa cystica* is a manifestation of hyperparathyroidism, has awakened the profession to this subject, and it has been quick to apply this knowledge not only to the diagnosis of this disease but also to its treatment. As a result of these studies, it has been found that the increased excretion of calcium and phosphorus in the urine not infrequently leads to the formation of urinary calculi (23 times in 83 cases). Occasionally, the precipitation of calcium phosphate occurs in the renal parenchyma, mostly in the collecting tubules, and leads to kidney contracture and insufficiency. In one case in this series a plain roentgenogram revealed in the region of each kidney stellate groups of punctate shadows outlining the pyramids. This observation of Fuller Albright, and his coworkers gave the clue to the proper diagnosis.

Based on the predominance of skeletal or urinary tract involvement and the degree of change in each system, several different types of disease are described. They state that, whereas "the disease may produce a fatal issue—usually from renal involvement—it probably smolders on for years, in the majority of instances crippling, but not killing."

In this connection, this contribution becomes very important both in the prevention and the treatment of urolithiasis, and it opens an entirely new line of thought to the student of the causation, course, prevention and cure of

urinary concretions and their many complications. Hypercalcemia has been previously recognized as present in brain tumors and the occurrence of renal stones was considered as the result of the confinement necessary to its treatment.

Albright, Cope, Baird and Bloomberg<sup>1</sup> consider the subject of the physiology of the parathyroid glands. They review 83 cases of hyperthyroidism, and point out that "the presence of renal stone should suggest the possibility of hyperparathyroidism," and two cases are cited where this one finding alone led to such a diagnosis and removal of a parathyroid adenoma in each instance. They also conclude: "As regards the prophylactic therapy for the prevention of renal damage in hyperthyroidism, it is pointed out that fluids should be forced; that an alkaline urine should be avoided; that ammonium chloride and presumably other acidosis producing salts are contraindicated; that a high phosphorus diet, while indicated for the demineralization, imperils the kidneys and should be used only when the blood values can be carefully followed; and that the same applies to a high calcium diet, although to a less extent."

## REFERENCE

<sup>1</sup> Am. Jour. Med. Sci., 187, 49, 1934.

## AIR PYELOGRAPHY\*

OWSLEY GRANT, M.D., AND ROBERT LICH, JR., MD.

LOUISVILLE, KY.

THE EMPLOYMENT OF GAS OR AIR as a medium for outlining the pelvis of the kidney is not a new procedure in urology. There have been some difficulties following its employment, but, on reviewing the literature, each of these, apparently, was the result of the operator disregarding the fundamental principles of the method.

Pneumopyelography was introduced by von Lichtenberg and Dietlen,<sup>7</sup> in 1911, and met with favor for some 15 years. The English and American literature contains but an occasional reference to the method; and the series of cases reported by Hughes,<sup>4</sup> in 1938, is the most extensive. It is still used, but, we think, not to the extent that it should be. We do not recommend it as a routine, but feel that there is so much of diagnostic value to be gained by its employment that, if properly performed, it has an extensive field of usefulness.

The danger of air embolism has been the bugbear of the method, and it seems to us that by proper discrimination and strict technic the danger can be entirely obviated, if indeed, such danger really does exist. Air emboli have always been a disputed factor in medicine. But it is well to lean toward the side of safety, and in the procedure of pneumopyelography we feel that our technic is entirely free from any danger.

Certain gases, especially oxygen, were used in the past because it was thought to be more rapidly absorbed than air, but this means the employment of gas tanks and a manometer, and adds to the intricacy of the procedure and, to our minds, is not so reliable as the much simpler method we follow. If there be danger, Kornitzer<sup>5, 6</sup> pointed out in his discussion, it is due to hyperpressure in the kidney pelvis. This, of course, is equally true where liquid media was used. He maintained that since the renal capillary blood pressure was 30 Mm.Hg. (von Lichtenberg) the pressure within the renal pelvis must not exceed 30 Mm.Hg. During the short life of gas pyelography several instruments were developed so that one could observe the exact pressure created in the renal pelvis. However, it has been our experience that by using a No. 5 F ureteral catheter, and injecting air or fluid without force, that the attached manometer never reads above 25 Mm.Hg. Hence, we have used a technic essentially that described by Hughes,<sup>4</sup> though developed independently.

*Technic of Air Pyelography.*—A 10 cc. Luer syringe, fitted with an adapter which contains cotton to filter the air, is used to inject the kidney pelvis. Two facts about the catheter are important: (1) It should be of small size, pref-

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

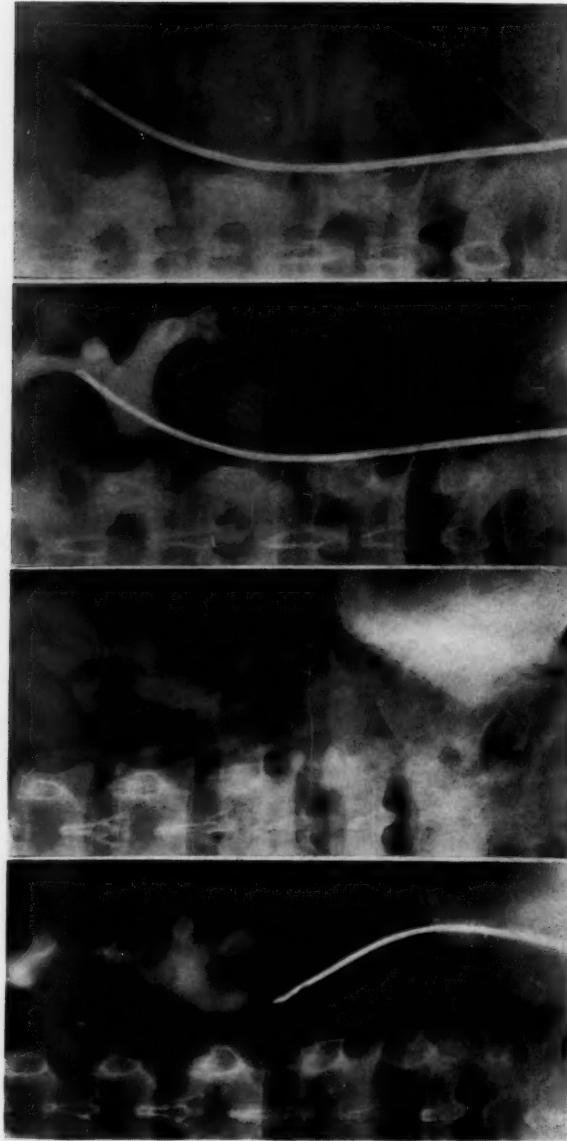


FIG. 1.—Pyelogram with Skiodan showing filling defects suggesting calculus at upper part of renal pelvis.  
FIG. 2.—Same picture made with air distention of pelvis showing marked contrast between stone and media.  
FIG. 3.—Pyelogram with Skiodan media showing suggestive filling defect in type of lowest calix.  
FIG. 4.—Same case showing air pyelogram with definite contrast between stone and media.

## AIR PYELOGRAPHY

erably a No. 5 F, so as to permit any possible backflow of air along its side into the ureter; and (2) it must lie in the pelvis of the kidney and not in the calix. This is accomplished by introducing the catheter until it drains. The pelvis is flushed with sterile saline and the catheter withdrawn until it ceases to drain. It may be assumed, then, that the catheter lies below the ureteropelvic junction. It is then reinserted, 0.5 cm. at a time, until drainage is reestablished, and we can feel certain, then, that it lies in the renal pelvis and is not impinging on any renal tissue, and thus give any opportunity for the production of air emboli.

The air is then injected slowly and, after a little practice with a manometer, the operator can readily estimate his pressure, which should not exceed 30 Mm.Hg. The patient should be in the erect or semi-erect position, so that the air ascends readily. If 10 cc. of air can be injected without discomfort, a roentgenogram is taken. Regardless of how little air is injected, if the patient complains of pain or fulness in the back, no further air is introduced until a roentgenogram has been taken. If the same care is exercised in making air pyelograms as in the use of fluid media, we feel there is no increased hazard in its employment.

The contraindications are in all cases where a retrograde pyelogram would be inadvisable and in cases of frank, marked renal hematuria.

We often employ the air and opaque media pyelogram in the same patient, in order to emphasize or detect certain points. In these cases, it is necessary to employ the air pyelogram first, because residual opaque media will, if that substance is used first, tend to confuse the diagnosis.

One definite advantage of air pyelography is its rapid absorption. We have followed this through a series of normal and abnormal kidneys, and find the average time for complete disappearance to be between three and seven minutes. This obviates the leaving of a heavy media in the pelvis in certain cases, which often causes severe postcystoscopic pain in an obstructed pelvis.

*Indications.*—We do not employ air as a routine, because, we believe, it does not give as distinct a picture of the calices as does opaque media injected in the Trendelenburg posture. But we have found it of inestimable value in accurately and positively locating the position of small stones or fragments of large stones, so necessary to be removed and so easily overlooked. In the presence of stones, the opaque media covers them entirely and their exact location is often a matter of guesswork. In air pyelography the contrast between the opaque stone and the nonopaque air presents a distinction that is most striking and will locate even a small fragment most precisely.

Air pyelography finds its greatest use in calculous disease of the kidney; and we feel accomplishes a purpose there unobtainable by any other method.

When used with care, we believe it is no more hazardous in those cases where it is indicated than the halogen pyelogram.

It is, unquestionably, less irritating to the patient and causes less post-operative reaction.

The air may be left in an obstructed pelvis to diagnose an occlusion or aberrant renal vessel or kink with impunity; and with the knowledge that it will be quickly absorbed.

In our experience we have never had the slightest untoward effect, and are impressed by the satisfaction it affords both the urologist and the patient.

#### REFERENCES

- <sup>1</sup> Bruger and Fuchs: Quoted by Kornitzer.<sup>6</sup>
- <sup>2</sup> Gilles, C. L., and Kerr, H. P.: Roentgen Diagnosis of Lesions of the Upper Urinary Tract. *Radiology*, **28**, 565-575, May, 1937.
- <sup>3</sup> Granger: Oxygen in Cystography and Pyelography. *Am. Jour. Roentgenol.*, **3**, 351-354, July, 1916.
- <sup>4</sup> Hughes, B.: Diagnostic Value of Air Pyelography. *Penn. Med. Jour.*, **41**, 897-899, July, 1938.
- <sup>5</sup> Kornitzer, E.: Pneumopyelography. *Wien. klin. Wchnschr.*, **39**, 1157-1159, September 30, 1926.
- <sup>6</sup> Kornitzer, E.: Defense of Pneumopyelography. *Wien. klin. Wchnschr.*, **40**, 1203-1205, September, 1927.
- <sup>7</sup> von Lichtenberg, A., and Dietlen, H.: The Demonstration of the Kidney and Ureter with X-ray Following the Introduction of Oxygen. *Munchen. med. Wchnschr.*, **58**, 341-344, 1911.

## THE SURGICAL TREATMENT OF ARTHRITIS\*

FRANK D. DICKSON, M.D.

KANSAS CITY, Mo.

ARTHRITIS, monarticular and polyarticular, constitutes one of the most important medical problems of our day. This is so because arthritis has not only a medical aspect, entailing pain and suffering, but also has an economic aspect which arises from the frequency with which it causes partial or complete incapacity, the result of the serious joint disturbances and deformities which it creates. Such deformities are more serious so far as the patient is concerned than any other feature of the disease, since they persist and frequently grow worse after the arthritis has become quiescent. While, during the past two or three decades, intensive study has cleared up many obscure features of the disease, little attention has been directed toward the prevention of the deformity, and the condition of the patient in the advanced stages of chronic arthritis is, in consequence, pitiable. With major joints fixed in faulty position, hands deformed and useless, feet swollen and distorted, muscles wasted, and confined to bed or wheel chair, they present a picture of complete invalidism. Such a situation could not help but be a challenge to modern surgery, and surgery has responded to this challenge by devising a number of procedures for the relief of the arthritic cripple. Some of these procedures have failed to justify themselves and have been discarded or modified, but a number have withstood the test of time and are of great service in relieving pain, bringing about, to a most satisfactory extent, improvement in joint function and restoring to useful activity severely incapacitated individuals. It is proposed here to briefly discuss those surgical procedures which have been found to be most worth while in rehabilitating the arthritic cripple.

Before proceeding with a discussion of the specific surgical operations available for the relief of the arthritic cripple, it is necessary to state the indications which call for surgical intervention, and to set up criteria which will aid in determining when such surgical intervention should be initiated, and what form it should take.

There are two indications for surgical intervention in the arthritic patient: (1) Incapacitating disability; and (2) the necessity for removing a focus of infection which is active in propagating the disease.

As to the first of these indications: In the arthritic patient a number of joints may be impaired in function and cause comparatively little incapacity; while, on the other hand, impairment of one or two important joints may result in a high degree of disability. In the upper extremity, loss of the shoulder, elbow, and wrist joints may place the individual in the same situa-

\*Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

tion as the armless, so far as eating and the acts of toilet and personal care are concerned. In the lower extremity, loss of function in the hip, knee, and ankle joints interferes with locomotion and the ability to get up and sit down without assistance; when both extremities are affected, the individual must lead a bed or wheel chair existence. Under such conditions, even if economic independence cannot be restored, the social betterment to be anticipated may justify the attempt to make life more livable and satisfactory.

The removal of foci of infection through surgery on one or more joints has a very definite place in the treatment of arthritis, in the opinion of many. In certain types of polyarthritis, particularly the so-called villus form, characterized by boggy, swollen joints, showing some degree of activity, the actively inflamed synovial membrane is definitely under suspicion as a focus of infection, which rivals the teeth and the tonsils as a source for the propagation of the disease. It has been our experience that the removal of such diseased synovial membrane results in improvement in the systemic disease in a very considerable proportion of cases. For example, in 27 cases of polyarthritis in which the operation of synovectomy was performed upon one or more joints, 22 cases showed marked and continued improvement in other joints previously painful and impaired in function.

Two factors are important in appraising the situation in the arthritic patient as to the most favorable time for operation and the type of operation to be employed when surgery comes into consideration. These two factors are: (1) The nature of the joint involvement; and (2) the extent of the joint damage present.

The nature of the joint involvement has a very important bearing on the time of surgical intervention. Chronic arthritis to-day is subdivided into two main types: (1) Atrophic or rheumatoid arthritis; and (2) hypertrophic or osteo-arthritis. The former is characterized by multiple joint involvement and a subacute course, with frequent exacerbations of acute joint inflammation; its pathology consists in destructive proliferative joint changes which eventually lead to partial or complete ankylosis. Osteo-arthritis is characterized by slowly developing degenerative joint changes, which may affect a few or many joints; its course is never acute, and it practically never leads to bony ankylosis. In the atrophic type of arthritis, surgery should not be undertaken until all acute symptoms have subsided, and the joint has become reasonably quiescent. In the hypertrophic type, there is, strictly speaking, never any acute stage, and surgery may be undertaken at any time.

The extent of joint damage determines largely the type of operation which is performed. The joint structures which are involved in any arthritic process are the ligaments, the synovia, the articular cartilage, and secondarily, the muscles which control the joint. When joint deformity and impairment are due solely or largely to thickening and contracture of the ligaments and muscles, one type of surgery is indicated, for example, manipulation or capsuloplasty. With thickening and active infection of the synovia and serious damage to the articular cartilage, the operation of synovectomy may be em-

## SURGERY OF ARTHRITIS

ployed. If there is complete disintegration or ankylosis of a joint, arthrodesis or arthroplasty must be resorted to.

Surgery, then, may play a successful rôle in the relief of the arthritic patient when the arthritis is in the quiescent stage, the pathology present has been properly evaluated, and loss of function in important joints has resulted in incapacitating disability. When these criteria are met, it is frequently possible in properly selected cases by a carefully planned surgical attack on one or more joints to convert a helpless invalid into a reasonably active individual, who can take care of himself and at times become self-supporting. In planning such a reconstruction campaign, it should be recognized that surgery in arthritic cases has three objectives: (1) Relief of pain; (2) the correction of the deformity; and (3) the restoration of function. Frequently, the first two of these objectives are one; more often than is realized, pain in the arthritic joint or joints is not caused by active disease, but is the result of strain on damaged or deformed joints with associated muscle spasm. Such pain can be relieved only by correcting deformity. These three objectives may be reached by several different types of operative procedure. The following are those most commonly employed.

- (1) Manipulation: Employed when the capsule and ligaments are the chief cause of joint deformity.
- (2) Capsuloplasty: Employed when the capsule and ligaments are the chief cause of joint deformity.
- (3) Synovectomy: Employed: (a) To remove a focus of infection; (b) when there is extensive involvement of the synovia and articular cartilages, and a badly damaged but salvageable joint.
- (4) Arthroplasty: Employed to restore motion in ankylosed but important joints.
- (5) Arthrodesis: Employed when joint damage is so complete as to preclude the restoration of useful function in a joint where stability is more important than movement.

*Manipulation.*—Manipulation, although it has fallen into some disrepute because it is so often confused with the cult of osteopathy, is a very important part of the armamentarium of the surgeon. It is particularly useful in the correction of the less severe arthritic joint deformities, due to contracture of the ligaments, capsule, and muscles without serious joint damage. Manipulation, always carried out under an anesthesia, should employ only gentle maneuvers; rough and forcible manipulation, as a rule, excites a severe local reaction, which usually results in a rapid return of deformity and decreased joint motion. Following manipulation, carefully supervised active movements should be started within 12 to 24 hours, and the range increased from day to day in order that full advantage may be taken of the improved position and range of movement in the joint. It is, as a rule, undesirable to fix in plaster a joint which has been manipulated; and if such fixation is carried out, it should be for only a few days. If a joint is immobilized longer, there

is danger of losing much of the movement gained by manipulation. Traction is much better than plaster for fixation purposes. Manipulation is best adapted to the correction of mild contractures of the knee, shoulder, wrist, and feet.

*Capsuloplasty.*—Patients with chronic arthritis show a decided tendency to develop flexion contractures of the joints, especially the knee, hip, elbow, and fingers. Such flexion contractures result from the patient's attempts to ease pain by maintaining the joint in a position which gives the greatest relaxation to the capsule. As time goes on, a fibrosis and thickening of the capsule takes place, its elasticity is lost, and it becomes an unextensible, fibrous band, which holds the joint fixed in flexion, resists efforts at correction, and tends to draw the joint back into deformity, even if a certain amount of correction is obtained. Later, the muscles on the flexor aspect of the joint shorten and add to the deforming force. Under such conditions, attempts to overcome flexion deformity by manipulation are doomed to failure, or if accomplished by the use of great force, ankylosis usually results. The deformity can be overcome, however, in such joints, and a useful amount of joint movement preserved by the operation known as capsuloplasty. This operation has for its purpose lengthening the contracted joint capsule sufficiently to allow complete extension of the joint without the use of force. To perform such a capsuloplasty, on the knee joint, for example, lateral incisions are made on the sides of the joint, and the posterior compartment of the knee is entered. The capsule will be found to be thickened and closely adherent and plastered to the distal end of the femur and the proximal end of the tibia, practically obliterating the posterior joint space. The adherent joint capsule and ligaments are carefully and thoroughly stripped from the lower end of the femur and the upper end of the tibia for a distance of from six to eight inches or more. When this has been accomplished, the capsule will be found to be quite relaxed, and the knee can usually be brought into complete or nearly complete extension with the use of little force. After closure of the wound, a plaster encasement may be applied or traction employed to hold the knee in extension and overcome what slight residual flexion deformity may remain—we prefer traction. Motion should be started in a week and the range rapidly increased. If the contraction has been a right angle or an acute angle, full extension should not be attempted at the time of the operation but secured gradually by traction. Both vessels and nerves have become shortened, and too rapid extension will shut off the blood supply and interfere with nerve conductivity, either of which may cause disastrous results. Capsuloplasty on contracted knee joints which prevent standing and walking will enable the individual to become ambulatory. The operation is also useful in the correction of contracture of the elbow and fingers.

*Synovectomy.*—By synovectomy is meant the complete removal of an hypertrophied and diseased synovial lining which interferes with joint function. This procedure is of chief practical interest in the knee, since it has a large synovial surface which is easily accessible. The operation as applied

## SURGERY OF ARTHRITIS

to the knee consists in opening the joint widely by a parapatellar incision, dissecting out in its entirety the synovia of the anterior compartment of the knee, the removal of both semilunar cartilages, excision of all articular cartilage which has become eroded by the joint pannus, and carefully shaving off the degenerated superficial layer of the articular cartilage, which is considered sufficiently normal to be allowed to remain. The last step, removing all seriously damaged cartilage and shaving away all the degenerated superficial layer of the remaining cartilage, is most important, as pointed out by Magnusson, if a maximum of joint function is to be obtained. Contrary to the opinion of a number of observers, it is our belief that a synovectomy, performed in a complete way, is one of the most useful surgical procedures available for overcoming pain and disability in arthritic joints, provided the cases are properly selected. The type of case which benefits most from a synovectomy is the so-called villus arthritis, which is characterized by a boggy, swollen knee, fixed in a greater or less degree of flexion so that standing and walking are difficult or impossible. A properly performed synovectomy followed by carefully supervised after-care gives, in such cases, surprisingly satisfactory results, both as regards relief of pain and the return of useful function. Furthermore, in a very considerable proportion of cases operated upon, it rids the patient of a source of infection which is a chronic focus for propagating the disease. This latter contention has been denied by many qualified to hold an opinion. Too often, however, in our experience, have active and acutely painful elbow, shoulder, and wrist joints subsided after synovectomy has been performed on the knee joint and remained quiescent and improved in function, to allow us to accept any other point of view than that the removal of such a focus has a very beneficial effect on the systemic disease in a very considerable number of cases. Without attempting to be critical, it might be a proper reply to the doubters to say, "You did not perform a thorough synovectomy." Synovectomy is one exception, so far as we can determine, to the rule that the disease must become quiescent before surgery is resorted to, as it may be performed, and in villus arthritis should be performed, when moderate activity is still present. In addition to the knee joint, synovectomy is satisfactorily undertaken in the elbow, wrist, and ankle joints. In 64 synovectomies, performed upon 45 patients in our clinic, the results have been as follows:

Total number of operations.....	64
Excellent results.....	38 or 59.3%
Definite improvement.....	13 or 20.3%
Failures.....	6 or 9.3%
Results unknown.....	5 or 7.8%
Too early to determine.....	2 or 3.11%

In 27 patients in this series, with polyarthritis, synovectomy has been followed by complete subsidence or definite improvement in other involved joints in 22 cases, or 86.6 per cent.

*Arthroplasty.*—The operation of arthroplasty consists in making a new joint to replace one rendered stiff and immovable by arthritis. Such an artifi-

cial joint is produced by resecting a considerable amount of bone, reshaping the bone ends entering into the joint in such a manner as to allow motion in normal planes, and placing between the bone ends some tissue, usually fascia lata, to prevent recurrence of the fusion between them. The after-treatment consists in carefully supervised physical therapy. Arthroplasty should never be performed upon an arthritic joint until it is quiescent and has been so for at least six months. Formerly, arthritic cases were not considered suitable for arthroplasty. In recent years, however, it has come to be considered a very useful and beneficial form of surgery under proper conditions, since it gives a useful, movable joint in a high percentage of cases. Restoring motion to one or more joints frequently enables an almost helpless individual to become reasonably active; for example, to feed himself when ankylosed elbows have been given movement. The elbow joint gives the most satisfactory result from an arthroplasty—the knee yields excellent results also. The hip joint was considered to be a very unsatisfactory joint for arthroplasty until Venable and Smith-Petersen introduced the Vitallium cap. Since then, very satisfactory results are being obtained. At the present time, in both the monarticular hypertrophic type of arthritis of the hip and in ankylosis due to atrophic arthritis, the results of arthroplasty, using a Vitallium cap are so promising that it bids fair to replace arthrodesis of the hip joint which has, up to the present time, been the operation of choice in this type of case. The operation of arthroplasty is not simple, and the postoperative care is tedious and time-consuming. Therefore, great care should be exercised in selecting cases in which it is recommended.

*Arthrodesis.*—Arthrodesis is an operation designed to secure complete ankylosis in a joint which has but a limited range of motion, and what motion remains is painful. Though arthrodesis takes away motion, it substitutes a strong, rigid, painless segment of limb for a painful and poorly functioning one, and the presence of a stiff joint, if the joints above and below are movable, is not as incapacitating as it is generally believed. Although it is desirable that the joints proximal and distal to that arthrodesed be normal, some impairment of these joints is not a contraindication to the procedure, as frequently, function in the adjoining joints improves following arthrodesis, probably due to the relief from strain and reflex muscle contractures. The success of the operation hinges upon ankylosing the limb in the optimum position of usefulness, and in securing a firm, bony fusion; this latter is not always as simple as it may seem. However, with an adequate technic, use of a bone graft, and a sufficiently prolonged postoperative immobilization, ankylosis can nearly always be obtained. The greatest field of usefulness for arthrodesis is in the knee, wrist, and hip.

#### CONCLUSIONS

It may be said in conclusion that most patients affected with arthritis sooner or later reach a stage of quiescence; when this stage has been reached, surgery may be resorted to to correct disabling joint deformities, relieve pain

## SURGERY OF ARTHRITIS

for which they are responsible, and improve function. By employing one or more of the procedures which we have been discussing, it is usually possible, in properly selected cases, to restore useful function to one or more joints and thereby convert an invalid into an individual who can take care of himself and even become self-supporting. The number of persons seemingly incapacitated by chronic arthritis who are salvageable through surgery is large, and failure to give such patients the benefit of surgery is denying them an opportunity for improvement to which they are entitled. The purpose of this presentation is to indicate the pathway along which reconstruction may progress and to suggest a reevaluation of the arthritic cripple generally from the point of view of saving, through reconstruction surgery, something from the wreck which disease has left.

**DISCUSSION.—DR. CHARLES S. VENABLE** (San Antonio, Tex.) : As usual Doctor Dickson has covered a very large territory and said a great deal. I am particularly interested in the salvage of those unfortunates who are on their way to ankylosis, and who hope and pray for it in order to get away from a painful joint, or have come to have an arthrodesis performed.

Doctor Dickson showed one case with a Vitallium cup on the hip. It was my good fortune to put on the first or second Vitallium cup. It is interesting, because it is the only material we know of which is sufficiently passive in the tissues not to cause other disturbances. Dr. Kellogg Speed has devised one for the head of the radius, and Dr. Willis Campbell has one for the knee. The difficulty in the knee is still the question of production of periarticular tissue, which looks good in the beginning and then tends to deteriorate during the course of thickening. I have done two of the head of the humerus, which seems to be a good place.

The whole story is, as I said, one of salvaging these unfortunate individuals who have had to be put in the discard, from both the humanitarian and economic standpoint.

**DR. PAUL B. MAGNUSON** (Chicago) : Doctor Dickson has given us a very brief but concise idea of what he can do in the care of these various types of arthritis. The field is so large that it is practically impossible to do more than scratch the top. There are two distinct classes of arthritis to be considered; one is destructive arthritis—the rheumatoid type with thickened synovial membrane and destruction of the joint cartilage; the other is the hypertrophic or degenerative form.

We have obtained most impressive results in the degenerative form of arthritis which, in my opinion, is due to the sum total of the wear and tear of life on joints. When we say sum total, it is quite apparent that a number of causative factors must be taken into consideration. This is a condition which occurs in the latter half of life, not as rheumatoid arthritis, which usually occurs in the first half of life. Low-grade infection, toxemia, overweight, faulty weight-bearing, previous injury—all are contributing factors and all must be taken into consideration in the diagnosis. Toxemias, whether they be due to metabolic disturbances or intestinal disturbances, must be eliminated. Low-grade infections, which pour nitrogenous toxins into the system, must also be eliminated. It is my opinion that many of these patients become progressively worse even after the systemic causative factors have been eliminated, because the joint is already rough, and the continuation of the trauma of movement

on the rough joint surfaces continues to irritate the joint and makes the disease progressive.

We have opened more than 80 of these joints, 63 of them being in the degenerative type of arthritis, and have removed the irritating material. Every bit of rough cartilage and all the exostoses have been thoroughly cleaned out, even down to bare and bleeding bone. The joint has been brought back into proper weight-bearing line and early motion is started after operation.

There are two distinct types of degeneration in this particular phase of arthritis. One type starts on the surface of the cartilage and progresses toward the matrix. This seems to be confined to cases which are purely traumatic in origin, from faulty weight-bearing, injury, overweight, or some mechanical factor, but it progresses to complete erosion and degeneration of cartilage if it is allowed to do so. We have been able to reproduce this type of arthritis in dogs, by causing faulty weight-bearing or instability of the joint, and allowing the animal free range to run; the disability does not occur if the animal is kept in close confinement where the joint is not traumatized by active motion.

The other type of degeneration starts at the matrix and progresses toward the surface, and is cone-shaped with the apex pointing toward the surface. The degenerative area is much wider at the base and there are no healthy cartilage cells growing from the matrix. When the degeneration reaches the surface a fissure is formed, and the edges of the surrounding cartilage degenerate and become rough, with stringy fibrous tissue protruding into the joint like seaweed. We have not been able to reproduce this type of degeneration in animals, so far. The experimental work is still in progress. This type, we believe, is tied up in some way with nutritional factors. It does not always occur on weight-bearing surfaces first, as does the other type of degeneration. It may appear anywhere in the joint, although usually more severe on the weight-bearing surfaces, probably because of the friction caused by motion.

The fact remains that in both these types most startling results are obtained when all this rough material is cleared away, and we believe that joint débridement will give highly satisfactory results if properly and carefully done, even in patients of advanced age.

DR. FRANK DICKSON (Kansas City, Mo., closing): I personally owe a great deal to both Doctors Venable and Magnuson, for what I have been able to do with some of these arthritic joints. I merely wish to say that most arthritic cases sooner or later reach a stage of quiescence, and at this time by properly planned surgical attack on one or more joints, it is frequently possible to restore an arthritic cripple to comfortable living and sometimes to economic independence. The number of persons seemingly incapacitated by chronic arthritis who are salvable through surgery is large, and failure to give such patients the benefit of surgery is denying them an opportunity for improvement to which they are entitled. It would then seem worth while to reevaluate our arthritic cripples generally, from the point of view of saving, through reconstruction surgery, something from the wreck which the disease has left.

## BRIEF COMMUNICATION AND CASE REPORT

### SPONTANEOUS RUPTURE OF THE COMMON BILE DUCT\*

E. DUNBAR NEWELL, M.D.

CHATTANOOGA, TENN.

A THOROUGH REVIEW of the literature shows very few reported cases of this interesting condition. A large majority of the cases that have been reported are early or late sequelae of operative procedures upon some portion of the biliary duct system. Several reports were also found of traumatic ruptures of the bile ducts; we were, however, able to find only two references to spontaneous rupture of the common bile duct not associated with trauma, operation, or impacted stone in the duct, namely, one by Bailey,<sup>13</sup> and the second by Vale and Shapiro.<sup>4</sup>

We have found several discussions of biliary peritonitis following transudation, or "weeping," of bile from either the duct system, the gallbladder, or from the bile radicals under the capsule on the surface of the liver. However, we feel that this diagnosis is not plausible unless the condition is actually observed, and that the etiology differs from the case herein reported.

**Case Report.**—W. G. T., white, male, age 63, was referred by Dr. D. O. Wright, of Fort Payne, Ala. His family and personal history were essentially irrelevant. He had had an appendectomy in 1926; and had had mild diabetes for the past ten years. *Chief Complaint:* Severe pain in the abdomen.

*Present Illness.*—The patient had been under the care of a physician for the past three years, during which time he had had at least eight attacks of severe epigastric distress and digestive disturbance, followed on several occasions by mild jaundice. Relief was obtained by rest in bed and the dietary measures usually employed in gallbladder disturbances. Between attacks, the patient's only complaint was eructation and mild dyspepsia, bearing no relation to his meals or other natural functions. Occasionally, during the attack of acute pain, he required a hypodermic of morphine for relief; however, the pain at no time lasted longer than 12 to 24 hours. Occasionally, during an attack, he complained of pain under the right scapula.

The last attack, prior to the present illness, was two weeks previous to admission to the hospital, following which he stayed in bed two days and recovered without undue difficulty. The present attack occurred 30 hours before admission; the initial pain occurring below the right costal margin and extending rapidly over the entire abdomen. He was examined, immediately following the attack, by his physician who stated that the attack was no different from the others from which he had suffered previously, and the usual rest, diet, and medication were advised and administered. However, ten hours following the onset of the attack, the patient vomited a large quantity of bright red blood and, when examined on this occasion, he presented board-like rigidity of the abdomen. Immediate hospitalization was refused. The patient continued to vomit and continued to have severe pain in his abdomen. He consented to hospitalization 30 hours following the initial attack of pain.

\* Read before the Fifty-third Annual Session, Southern Surgical Association, Hot Springs, Va., December 10, 11, 12, 1940.

*Physical Examination.*—The patient is an asthenic white male, age 63, conscious, rational, and acutely ill. Pulse 80; blood pressure 180/100. Examination was otherwise negative except for that relevant to the abdomen. This showed an old appendectomy scar. There was board-like abdominal rigidity, with tenderness over the entire abdomen, most marked in the epigastrium. Urinalysis was normal, except for a trace of sugar. W.B.C. 13,250, 83 per cent neutrophils. The patient was given 1,000 cc. of glucose intravenously; and immediate operation was advised. *Preoperative Diagnosis:* Ruptured peptic ulcer.

*Operation.*—Under cyclopropane anesthesia, the abdomen was opened through a right upper midrectus incision. There was an immediate gush of bile-stained fluid. The pylorus was found to be normal. The stomach showed no indication of pathology. Palpation of the head and body of the pancreas revealed no evident abnormality. The gallbladder was small, approximately one-third normal size, thick-walled, with surrounding dense, fibrous adhesions. It contained no stones or bile; there was, however, a small amount of white fluid. It apparently had not functioned for a number of years. The common duct was exposed and found to be dilated to approximately four times normal size, throughout its entire visible length. Further inspection revealed a small bile-discolored effusion beneath the peritoneum, overlying the common duct at approximately the junction of the common hepatic and cystic ducts. An incision was made through this peritoneum and a small amount of bile escaped. However, careful inspection showed no evidence of any opening into the common duct. An adequate incision was then made in the common duct, the walls of which were thickened and edematous. A large amount of common duct "mud" was obtained and several small cholesterol stones, approximately 2 Mm. in diameter. Following cleansing of the common duct, a probe was easily passed into the hepatic ducts, and a large blunt dilator was, also, easily passed through the sphincter of Oddi into the duodenum. Very little resistance was met during this maneuver and no stones were encountered. The cystic duct was found to be completely occluded by scar tissue. The common and hepatic ducts were washed out with saline solution. A small catheter was sutured in place in the common duct. The gallbladder was removed. A rubber tissue drain was placed down to the gallbladder bed and catheter, and brought out at the middle of the wound. The wound was sutured in layers. The patient was returned to bed in moderate shock, from which he recovered rapidly.

*Postoperative Course.*—Convalescence was fairly smooth; and the catheter was removed 12 days following operation. The biliary fistula healed rapidly. He was discharged 20 days following operation, apparently in excellent condition.

*Follow-Up.*—One year following operation: Excellent condition. No epigastric discomfort. Has gained approximately 15 pounds in weight, and apparently is perfectly well and healthy.

*Comment.*—Several interesting features present themselves in regard to the pathology in this patient. The case is undoubtedly one of bile peritonitis following an acute, spontaneous rupture of the common duct. However, at the time of operation, we found no indication of obstruction in any point in either the common or hepatic ducts which might account for a rupture of the duct from undue pressure. The liver, examined carefully at the time of operation, presented no evidence of chronic hepatitis or injury from partial common duct obstruction. The patient at no time, throughout his history or during his hospitalization, had any clay-colored stools, severe jaundice, or any indication of complete obstruction of the common duct.

We believe that the gallbladder was nonfunctioning, and that the dilatation of the common duct may be explained on the basis that the function of the gallbladder was assumed by the common duct following atrophy of the former. The small stones and common duct "mud" found at operation may easily have been accounted for by the stasis in the common duct, inci-

## RUPTURE OF CHOLEDΟCHUS

dent to its dilatation. The only plausible explanation we can offer for rupture of the common duct is that the patient had a chronic choledochitis with an acute exacerbation, and edema or spasm of the sphincter of Oddi, causing temporary partial obstruction and a subsequent empyema of the common duct, with rupture occurring at the weakest point in its infected wall. Another possibility is that this patient had a small stone imbedded in the wall of the common duct with surrounding infection causing acute perforation.

Burden<sup>6</sup> in 1925, in a paper on "Histologic and Pathologic Anatomy of Hepatic, Cystic, and Common Bile Ducts," probably found the correct explanation for the perforation which must have existed in this case. His original study on the anatomy of the extrahepatic bile ducts indicates that these structures may well be subject to intrinsic pathology. He has shown that the biliary ducts contain numerous glands in their walls, extending almost to the peritoneal coat. Normally, these glandular structures are filled with mucous secretion, however, it seems entirely plausible that in a dilated, diseased duct, the glands might well be the site of infection or calculus formation, which, under unusual circumstances, would lead to perforation of the duct.

The conditions found at operation seemed to be quite similar in all reported cases.

Bailey<sup>13</sup> describes his case as follows:

"Pints of bile were found in the peritoneal cavity. Bile was also present in the lesser sac and behind the peritoneum, which was floated up. The gallbladder looked normal, but on palpation many tiny calculi could be felt. The stomach and duodenum were examined with a negative result. The cystic duct and supraduodenal portion of the common duct were examined with a seeker, but no perforation was demonstrable; indeed, these structures appeared quite normal. It is concluded that there was a perforation of some part of the hepatic or common bile ducts. Cholecystotomy and drainage of peritoneum were performed. Twelve hours later, he collapsed and died. A necropsy showed a perforation at the back of the junction of the cystic and common ducts."

Quoting further from Bailey:

"Biliary peritonitis without perforation was first described by Clairment and Haberer, in 1910. Professor Leriche records a case in which three pints of bile were found in the general peritoneal cavity. Bile was found to be dripping from a distended gallbladder. The pathology of the condition is obscure. The gallbladder in these cases is found to be very edematous and Marinacci believes that there is a minute perforation or perforations in its wall. This theory is plausible and should be assumed to be correct until further evidence concerning this rare condition is forthcoming."

In our case, there was no edema of the gallbladder, and no dripping of bile from the gallbladder.

The other case that is analogous to the one herewith reported, was that of Vale,<sup>4</sup> of Detroit, who stated:

"The gallbladder was chronically inflamed with thickened walls, and was filled with innumerable small stones. There was no point upon it which leaked bile. The stomach and duodenum were normal. The peritoneum covering the common duct, portal vein, and hepatic artery, was edematous, evidently having been dissected up by the presence of escaping bile somewhere beneath it."

He drained this case through the gallbladder and cystic duct; and the patient made a good recovery.

In the reported cases, the patients presented more or less the following picture: A history of acute, severe pain in the epigastrium, followed by vomiting, with a history of previous epigastric discomfort, resembling the present attack but not so severe; there may or may not be jaundice; when

first seen by the physician, these patients usually present a picture of a chemical peritonitis, with board-like rigidity of the entire abdomen, and tenderness directly over the epigastrium. The obvious diagnosis, and the one most frequently made, is ruptured peptic ulcer.

The only instance in which the rupture was actually located appeared to be at the autopsy table. As these patients are very ill, operation must be carried out rapidly, and as these perforations are usually very small, location at the time of operation would be needless and most difficult.

Of the two cases found in the literature, one survived and one died. The operative procedure in both cases was similar, the primary thought being to drain either the gallbladder or the common duct itself. No follow-up reports of these two cases were found.

**SUMMARY.**—A case of nontraumatic, nonobstructive, spontaneous rupture of the common bile duct is reported; with comments on two previously reported instances in the literature.

#### BIBLIOGRAPHY

- <sup>1</sup> Bumpus, H. D., Jr.: Rupture of the Common Bile Duct Associated with Subphrenic Abscess. *ANNALS OF SURGERY*, **64**, 414, October, 1916.
- <sup>2</sup> Garrett, R. W.: Traumatic Rupture of the Bile Duct. *ANNALS OF SURGERY*, **31**, 227, 1900.
- <sup>3</sup> Long, Le R.: Traumatic Rupture of the Bile Ducts. *South. Med. Jour.*, **22**, 236, March, 1929.
- <sup>4</sup> Vale, C. F., and Shapiro, H.: Nontraumatic Perforation of Common Bile Duct. *Am. Jour. Surg.*, **18**, 103, October, 1932.
- <sup>5</sup> Wolfson, W. L., and Levine, D. R.: Spontaneous Rupture of the Common Bile Duct. *Surg., Gynec., and Obstet.*, **60**, 746, March, 1935.
- <sup>6</sup> Burden, Verne G.: Observations on the Histologic and Pathologic Anatomy of the Hepatic, Cystic, and Common Bile Ducts. *ANNALS OF SURGERY*, **82**, 584, 1925.
- <sup>7</sup> Rudberg, H.: Traumatic Rupture of the Biliary Passages. *J.A.M.A.*, abstract, **79**, 1562, October 28, 1922.
- <sup>8</sup> Lewis, K.: Traumatic Rupture of the Bile Ducts. *ANNALS OF SURGERY*, August, 1938.
- <sup>9</sup> Newburger, B.: Spontaneous Postoperative Rupture of the Bile Ducts. *ANNALS OF SURGERY*, **107**, 558, April, 1938.
- <sup>10</sup> Lysaght, A. C.: A Case of Traumatic Severance of the Common Bile Duct. *British Jour. Surg.*, **646**, January, 1939.
- <sup>11</sup> Caulfield, E.: Bile Peritonitis in Infancy. *Am. Jour. Dis. Child.*, **52**, 1349, December, 1936.
- <sup>12</sup> Allen, A. W., and Wallace, R. H.: The Surgical Management of Stone in the Common Bile Duct. *Trans. South. Surg. Assn.*, **52**, 167, 1939.
- <sup>13</sup> Bailey, Hamilton (Eng.): *Emergency Surgery*. Vol. I, 103. Wm. Wood and Co., 1930.

#### EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M.D.  
1833 Pine Street, Philadelphia, Pa.

Contributions in a foreign language when accepted will be translated and published in English.

Exchanges and Books for Review should be sent to James T. Pilcher, M.D., Managing Editor, 121 Gates Avenue, Brooklyn, N. Y.

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY  
227 South Sixth Street, Philadelphia, Pa.